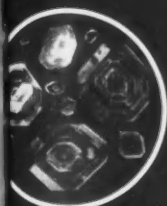
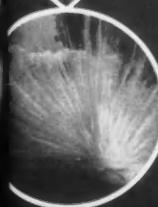


CHEMISTRY



**MARCH
1960**



Thirty-third
Year

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WOOD

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Editorial:

Youth at the Helm
Inside Front Cover

50¢

A SCIENCE SERVICE PUBLICATION

Youth at the Helm

► FOR THE LAST FEW WEEKS, the spot-light has again been on the youthful scientists who have been competing in the Nineteenth Science Talent Search. The project report submitted by the year's top winner is presented in this issue.

After nineteen years it is possible to determine the validity of S. T. S. grading in assessing scientific potential. There have now been 760 winners in all, and these have all, with the exception of those who are still too young, attended college. Ninety-three percent obtained bachelor's degrees, 60% master's degrees or equivalent, and 45% doctor's degrees. It is significant that S. T. S. finalists are earning doctorates at a rate nearly 25 times the national average.

Dr. Harvey C. Lehman of Ohio University in his paper, "Age and Outstanding Achievement in Creative Chemistry" (*Gesiatrics*, Vol. 15, Jan. 1960), has analyzed the correlation between importance and abundance of creative output, and age, for 57 of the most noted chemists up to the year 1900. His findings are too lengthy to be included in this editorial, but his conclusions are both interesting and significant. Dr. Lehman shows that "noted chemists who started their professional work earliest achieved both more abundant and more important creative output than did those who started their careers at older age levels." He further points out that there is no reason why these conclusions should not be equally valid for scientific fields other than chemistry. If this is the case, then it is from the S. T. S. winners and finalists that we may in the future look for the greatest contributions to American science.

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Editor: WATSON DAVIS

Assistant Editor: STEPHEN HISCOCKS

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944)

Editor in Memoriam: HELEN MILES DAVIS (1944-1957)

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► *THIS MODEL of a fireproofed wooden church shows how flames are restricted to the materials within. The model built with untreated wood does not contain the fire, supports the blaze, and soon collapses. Both models were stuffed with similar amounts of excelsior and were lighted at the same time.*

New Wonders from Wood

by LLOYD STOUFFER

► AFTER DECADES of research, the men who work with wood are doing things today that must change our whole concept of this ancient material. Putting chemicals into it, the laboratory men have confounded belief by producing wood that won't burn; wood that won't shrink, swell or warp; and wood that defies the attack of termites and decay.

Taking chemicals out of wood, they have created a wide variety of commercial products, including yeast, al-

cohol, adhesives, plastics — and the vanilla flavoring of your ice cream. From the synthetic vanilla have come valuable ingredients for cosmetics, perfumes, foods and drugs.

Most significant of all, they are on the verge of a scientific breakthrough which may furnish the world's chemical industry, now anchored largely to coal and petroleum deposits, with the basic materials of plastics, textiles and other chemical products from the renewable resources of the forests.

All this I have seen in a recent tour of government and industry research facilities, notably the great Forest Products Laboratory of the U. S. Department of Agriculture, at Madison, Wis., founded just 50 years ago as the world's first institution devoted exclusively to research in wood utilization. Here, in a vast building on the University of Wisconsin campus, more than 450 scientists and other workers are busy today sawing, cutting, cooking, treating and dissecting wood, working to fight enemies and to increase still further the value of what is already a 20 billion dollar industry.

Preserving Wood

The two greatest living destroyers of wood are insects and the fungi that cause rot. The FPL men can now lick them simultaneously with chemicals, either by poisoning them or by denying them food and vitamins. One method is treatment with creosote and other chemicals, under pressure. A new and simple method, called double diffusion, which merely requires the soaking of green wood alternately in water solutions of two chemicals, copper sulfate and sodium arsenate. These react with each other deep in the wood to form insoluble, toxic, copper arsenate, which is death both to insects and to the organisms of decay. Because it's insoluble, the poison remains permanently in the wood to knock off anything that might attempt to feed upon it. Fence posts treated in this way have remained unharmed after 18 years in the ground. Success of this method has stimulated belief that house lumber — particularly that destined for termite-infested areas — can be routinely soaked in baths of

the interacting chemicals just as it comes from the mill saw.

The starvation method is still experimental. But recently it has been discovered that the fungi of decay not only need food, they need vitamins — particularly thiamine (Vitamin B-1). Remove the natural thiamine from wood, and the fungi can't exist.

Fireproofing

The newest approach to the fireproofing of wood is the use of certain chemical salts (ammonium and boron salts form one combination) which are forced far enough into the wood under high pressure to give the whole piece a protective shield. Wood so treated simply won't support flames.

Some of these fire-resistant woods, when subjected to flame heat, even give off a gas which acts as a fire extinguisher. At the Cross, Austin, and Ireland Lumber Co., in Brooklyn, N. Y., they built two miniature frame houses — one using untreated plywood, the other treated by a fire retardant compound of the Koppers Company. Both houses were filled with kerosene-soaked excelsior and matches were applied. Three minutes later the house of untreated wood was a blazing ruin; in the other, the flames were dying out and the house remained structurally sound, although a bit charred.

Wood is now being chemically fireproofed by a number of plants using Koppers Company's latest compound, "Non-Com." Underwriters' Laboratories and fire rating bureaus give it a top rating. The New York City building code, one of the most rigid in the country, permits its use as structural members in many commercial

buildings where steel was previously required — allowing a substantial saving in cost. As against untreated wood, industry sources estimate that it would cost only five percent more to specify fire-proofed wood as against untreated wood for the average frame house.

Shrinking and Warping

Aside from its susceptibility to fire and decay, one of wood's great drawbacks has been its tendency to shrink, swell and warp with marked changes of atmospheric humidity — as every householder troubled with squeaking floors in the wintertime and sticking doors and drawers in summer well knows.

Originally, the only way to stabilize dimensions was to start with dry wood and keep it covered with finishes (paints, varnishes, drying oils and waxes) which would to some extent control moisture gain and loss. Later, the advent of cross-laminated plywoods gave improved stability through physical control of the forces of shrinking and swelling, and made possible such developments as the modern flush, hollow-core door. But plywood is not immune to warp.

In the '30s, FPL's Dr. Alfred J. Stamm said: Why not modify the wood itself, all the way through, by chemical treatment? After years of experimentation, Dr. Stamm developed a process by which phenolic resin — a plastic which remains unchangeable once it has been set by heat — could be impregnated into thin veneers; the veneers could then be bonded together with the same resin to provide material of the desired thickness. With the addition of 30 percent resin, the process, called Impreg, produces a wood so stable

that it is used to make die models for automobile bodies.

Then came the idea that if wood could be both resin-treated and compressed, removing the 60 to 70 percent of its bulk which is nothing but air, it would be much harder and suited to new uses. Development of the process, called Compreg, by which hardwood is compressed to half its natural thickness, has resulted in the very dense wood known as Pakkawood, which is widely used in knife handles because it is the only material suitable for this purpose which will withstand repeated automatic dishwashings without swelling, warping or cracking. There are 16 layers of hardwood veneer in a typical knife handle. The material is reduced under heat and great pressure, and at this point is 35 percent plastic.

Impreg and Compreg are still too expensive for widespread use. A single board foot of these materials costs several dollars. But this is only the beginning. Today a large part of FPL's time and manpower is devoted to finding cheaper ways of getting stabilizing chemicals into the wood. One indication is a process developed under Dr. Stamm by which lumber is simply soaked for days in a water-soluble wax, polyethylene glycol, and then allowed to dry slowly. The water evaporates and the wax remains, diffused throughout the wood. With further development, some such treatment as this, avoiding laminating operations and heat-curing ovens, may prove entirely practical for cabinetwork, furniture, and many other wood products, and end forever the problem of sticking and warping in doors and drawers.

Full economic utilization of wood includes the finding of jobs for off-grade, knotty lumber, and for the inevitable shavings, chips, flakes and particles that are left from milling operations. Previously this kind of wood has just gone up in smoke. FPL developed the idea of covering low-grade lumber with wet-strength paper, using weather-resistant resin adhesives. This would hide the defects, control the splinters, and give a good painting surface. Surprisingly enough, the paper surface also turned out to reduce swelling and shrinking of the board by as much as 50 percent — thus providing an actually superior product.

On FPL buildings I saw paper-covered, painted siding which has withstood several years of exposure, and in the University of Wisconsin stadium there are 300 seats still standing up well after five years. Even on boards that look like they've been gouged by trackshoe spikes the paper surfacings, called overlays, haven't peeled off.

Utilization of Wood Wastes

Very likely your new table or dresser is made up of thin veneers of fine wood covering a center core of what the industry calls "particle board." This is now produced by a number of firms simply by chipping wood scraps into flakes or particles, spraying them with a minimum of resinous glue, and forming them under heat and pressure into a "board." Not only is this low-cost core material moving rapidly into quality furniture, but it is showing good performance in place of plywood as sub-flooring.

Even better than utilizing wood wastes, obviously, is eliminating the waste in the first place.

Despite intensive research, few practical uses have ever been found for sawdust. So FPL now tries to minimize sawdust or eliminate sawing entirely. They demonstrated for me a new circular saw blade with peculiar teeth — alternately a long, thin tooth and a somewhat wider, short one. The long tooth makes a deep cut and the short one widens it, with the result that sawdust is reduced by 25 percent. Since with ordinary saws the annual production of sawdust in the United States is equivalent to 4.8 billion board feet of lumber, a little calculation shows that perfection and universal use of such a saw could save enough lumber to build up to 120,000 two-bedroom frame houses!

Even more intriguing is a big, guillotine-like machine which simply slices through huge logs, producing no sawdust at all. With the slicer, which will cut boards up to 1½ inch thick, it is possible to get one-third more lumber out of a log.

Chemicals from Wood

One of the most wasteful of all big wood-consuming processes is the manufacture of sulphite pulp, from which white paper and high-grade paperboard are made. After the cellulose fibers suitable for paper-making have been boiled out, half the original pulpwood literally goes down the drain as waste liquid. Half of this waste, or about 1,500,000 tons a year, is lignin — the "cement" which in the wood held the cellulose together — and another 25 percent is sugar made from the wood during the pulping.

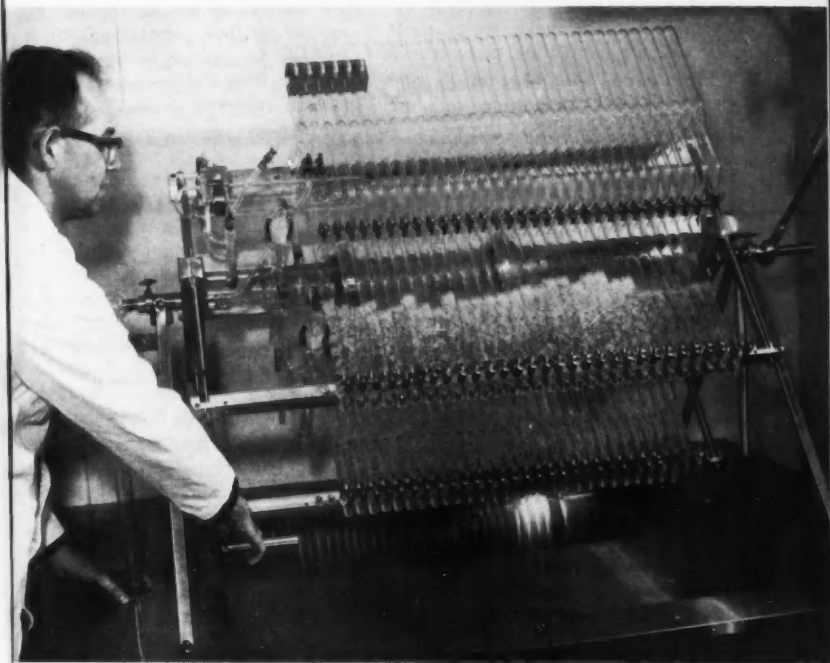
Chemists have long realized that lignin holds a number of fascinating chemicals, but it is only in recent years that they have found practical

ways of getting them out. The synthetic vanilla called vanillin, which now supplies more than half of the vanilla-flavoring market, is significant as the first of these to become commercially successful, but it is only a drop from an enormous chemical bucket.

About one percent of the national supply of lignin would keep the whole world supplied with vanilla flavoring. So chemists are busy fractionating and compounding vanillin to develop some entirely new chemical building blocks.

From vanillic acid, once a useless by-product of vanillin, they now make polyester plastics and fibers similar to dacron. They have produced useful ingredients for perfumes and cosmetics (including an effective suntan screen), an approved food preservative which is less toxic than the widely used sodium benzoate, a drug for the control of respiration and blood pressure, and a drug to combat skin fungus infections.

From the wood-sugar fraction of the spent pulp liquors, yeast and ethyl



➤ A SCIENTIST at the Forest Products Laboratory, Madison, Wisconsin, is extracting chemicals from wood with a Craig apparatus. The instrument makes use of counter-current distribution.

alcohol are being commercially produced. Forest Products Laboratories has shown that one type of wood sugar, xylose, may be economically converted to furfural, which is the basis of nylon — so it is now possible to derive a pair of stockings from a tree.

Derivatives produced from bark and from spent sulfite liquors are now standard components of vital oilwell drilling muds, helping to hold pressure in the wells. A useful fertilizer-soil conditioner can be made by a University of Wisconsin process from sawdust plus bark, and phenolic extracts from bark make an excellent adhesive for laminating plywood.

From wood itself comes a solid chemical rocket fuel, nitrated cellulose

which contains its own oxygen for combustion, and is used in the field of rocket propulsion.

All this looks like the beginning of a new chemical industry built on wood. "We're only about ten years away from it," says Dr. Edward G. Locke, FPL director. "In another 50 years, wood that's now discarded — the lignin alone — may be an important supplement to petroleum and coal as a source of industrial chemicals."

Thus our chemical economy can have another strong foundation in a material which is constantly being replenished by nature in the resources of the forest — and we can all breathe more easily.

This article is published in cooperation with READER'S DIGEST.

Rubber Paint Speeds Submarines

➤ A NEW RUBBER PAINT has been developed that will give submarines a more-yielding "skin" and may enable ordinary submarines to slip through the water at speeds approaching 70 miles an hour.

Further perfection of the paint, plus coming engine improvements, might lead to passenger and cargo submarines that could race across the oceans at 207 miles an hour.

Developed by Dr. Max O. Kramer, vice president of Coleman-Kramer, Inc., Los Angeles, the new rubber paint cuts down water turbulence around a body moving through the water.

United States Rubber Company's scientists compared the new ship paint to the pneumatic tire that advanced land transportation.

The present paint consists of a thin layer of rubber supported on the boat's surface by "a multitude" of tiny rubber pillars. A freely flowing viscous liquid is able to flow through the tiny caverns created by the rubber pillars and enclosed by the outside rubber coat.

These caverns give the coating flexibility and the supple liquid provides the necessary damping to suppress turbulence.

In tests with submerged bodies, the coating has cut water resistance, due to turbulence, in half. But scientists hope to improve the rubber paint further, because most ships use 70% to 90% of their propulsive effort to overcome this drag. By reducing turbulence, more engine power can be used to speed the vessel.

Nuclear Magnetic Resonance

by JAMES C. W. CHIEN

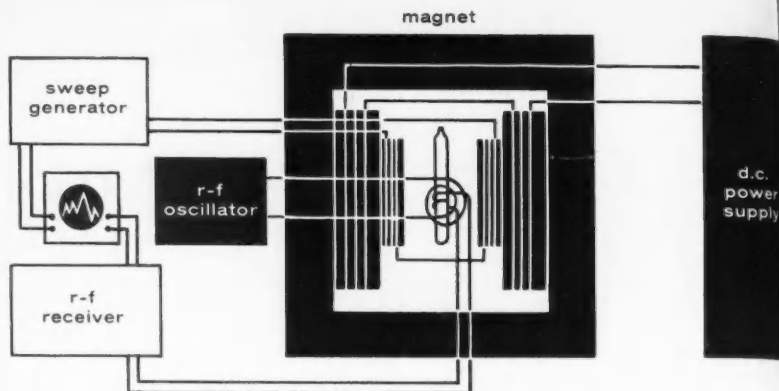
Reprinted from Hercules Chemist

► IT WOULD BE real nice if chemists had a little black box into one end of which they could place a sample, then press a button and from the other end there would emerge a printed tape telling the composition, chemical structure, and anything else they wanted to know about the sample. At the moment no such little black box exists, but chemists have come a long way from the days when conventional gravimetric and volumetric analytical procedures were the only tools available for identifying and measuring quantities of materials. Modern spectrophotometers operating in the ultraviolet, visible, near infrared, and infrared regions of the electromagnetic radiation wave-length scale have greatly simplified identification of materials. Other techniques, such as chromatography, have been of tremendous help. The newest and most exciting approach to this problem of finding out all there is to know about a material, quickly and accurately, bears the somewhat formidable label nuclear magnetic resonance. When abbreviated to n.m.r. it doesn't sound so difficult.

The n.m.r. analysis is not made in a little black box; the equipment is rather large and fairly complex. The results do not come out printed on a tape in plain English; they come as a chart which requires a somewhat involved mathematical interpretation. But in a half-hour seance with n.m.r., one can learn things about a material that would require months to learn

with other means of investigation, and one can learn some things that could not be definitely ascertained by any other method. So it is no wonder that n.m.r. has captured the interest of physicists and chemists, especially chemists, and that it has gained wide acceptance as a research tool in the short time since the principle was discovered, independently but almost simultaneously, by E. M. Purcell of Harvard University and F. Bloch of Stanford University, in 1946.

Perhaps the simplest way to explain n.m.r. is to think of it as a form of spectroscopy. *In n.m.r. spectroscopy, the wavelength at which a certain change in energy level of the nucleus occurs is determined.* The procedure is analogous to spectroscopy utilizing visible light (3.8 to 7.8×10^{-5} cm. wavelength), but, in the case of n.m.r., using wavelengths in the region of those used for FM radio (around 500 cm.). Instead of placing the sample in a beam of light it is placed in a magnetic field; instead of a prism or diffraction grating to cause the radiation to diverge into a spectrum, a sweep generator alters the current which energizes the magnet; instead of a photoelectric cell as the detector or observer a radio-frequency receiver is used. In terms of equipment and operation this analogy is substantially correct, but in terms of what actually happens it leaves much to be desired. Also, if one considered n.m.r. equipment as only a spectroscope to record emission or absorption of particular



► THE ABOVE DIAGRAM shows the essential elements of a nuclear magnetic resonance spectrometer.

wavelengths of radiation, one would lose much of its value.

N.m.r. was developed by physicists studying the structure of matter, particularly in regard to nuclei and their relative positions with respect to one another. Instead of being an apparatus to record a phenomenon that was not understood, n.m.r. equipment was devised to demonstrate that a mathematically predictable phenomenon would occur as predicted.

As the name implies, nuclear magnetic resonance deals with nuclei. A proton (hydrogen nucleus) can be pictured as an electrically charged, spherical, spinning body. The spinning motion of the electric charge generates a magnetic field, i.e., the spinning proton is a tiny magnet. Let's skip the quantum mechanics involved and simply state that the magnetic moment m , of spinning nuclei, must be either $m = +\frac{1}{2}$ or $m = -\frac{1}{2}$ and that the nuclei having a magnetic moment of $m = +\frac{1}{2}$ will align

with the external magnetic field (like compass needles all pointed north). Those with $m = -\frac{1}{2}$ will also align but in the opposite direction. Furthermore, there will be *slightly* more of the $m = +\frac{1}{2}$ variety. For instance, in an external field of 9,400 gauss, at room temperature, the ratio will be 1.0000066 to 1. *The basis of n.m.r. is the transition of the slight excess population of the more favored state of $m = +\frac{1}{2}$ to the spin state of $m = -\frac{1}{2}$ by excitation.* The excitation is produced by an oscillating magnetic field superposed on the primary magnetic field in a plane perpendicular to it. By holding the direct current electromagnet at constant intensity and varying the frequency of the oscillating field, or vice versa, by varying the intensity of the d.c. magnetic field while maintaining a constant frequency of the oscillating field, a point is located at which the desired transition occurs. This is the resonance point and at this point the detector picks

up and records a slight change in voltage produced by the change in energy level accompanying the transition. Data are available from which the resonance frequencies of all spinning nuclei may be calculated.

A magnet for n.m.r. work, while not in the same class with the tremendous magnets used in cyclotrons, is a husky unit. The n.m.r. instrument used at Hercules Research Center has a magnet that will take up to 2.0 amperes of direct current at 2,500 volts and produces a magnetic field of over 14,000-gauss intensity. Some of the differences in resonance one wishes to observe in chemical investigations result from a change of less than 0.2 milligauss in the magnetic field intensity. It is apparent, then, that this big magnet must be equipped with some very accurate controls.

In this particular instrument, the radio-frequency oscillator that supplies the excitation radiation is kept at a constant frequency (for protons it is 60 megacycles per second) and the current on the d.c. magnet is increased at a controlled rate over the range desired. The record on the chart is the strength of signal picked up by a radio-frequency receiver, plotted against increasing intensity of the magnetic field. In order to interpret the results more easily, distances on the x axis are converted to frequencies, thus making the chart read as though the magnet had been kept constant and the frequency of the oscillator varied. The chart then shows strength of signal plotted against excitation frequency, in cycles per second, and any sharp peaks indicate resonance frequencies.

Now what do these peaks mean?

The resonance frequencies of the nuclei of elements which have spinning nuclei differ. For example, in a field of 14,100 gauss the oscillation frequency for hydrogen (H^1) resonance is 60; for fluorine (F^{19}), 56.6 megacycles per second. So chemical elements can be identified; but if this were all there was to n.m.r., chemists would not be much interested. The interesting feature is that when an element becomes a part of a chemical compound the electrons and neighboring nuclei around it change the apparent nuclear magnetic field slightly, thus causing a shift in the resonance frequency. From this shift the position of the nucleus in relation to its neighbors can be located, and the chemical environment of the nucleus can be deduced, and therein lies the ability of the method to tell all.

Take hydrogen, for example. The spectrum of a hydrogen-containing compound consists of a number of resonance peaks. These peaks are produced by chemically different protons; the position of each peak gives a clue to the chemical environment of that proton, and the area under the peaks in many cases indicates the number of protons of that kind. From such data one can differentiate between aromatic, ethylenic, acetylenic, hydroxyl, cyclic, amine, mercaptan, and aldehyde protons. One can differentiate also between protons on terminal and nonterminal unsaturated carbon atoms, between cis- and trans-isomers, between axial and equatorial substitutions. Other difficult structural problems can be solved.

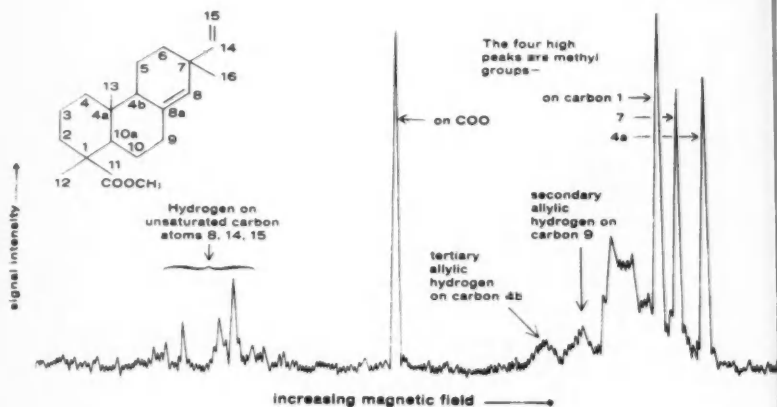
Using n.m.r., rate constants can be established for reactions which are too fast for other methods of studying

kinetics. Polymer chemists can determine with n.m.r. some of the fine points of polymer structure that have a bearing on properties of plastics. These two widely different applications of n.m.r. are cited to indicate its versatility.

One of the uses made of n.m.r. at Hercules Research Center has been to answer questions concerning the structure of some of the acids found in rosin, and of related terpenes — questions that had remained unanswered after years of intensive research. For instance, by consideration of the numbers of olefinic, secondary allylic, and tertiary allylic protons, and the shifts of various methyl groups, the positions of double bonds in several resin acids which were previously uncertain have now been assigned.

Having considered the general prin-

ciples involved in n.m.r., and some of the things that can be accomplished with it, let's go back to the equipment. A sample of 0.1 gram is sufficient. The sample is not destroyed by the analysis and can be recovered unchanged. The sample is dissolved in a solvent such as carbon tetrachloride which contains no protons, or a solvent such as benzene which gives only one peak. The container for the sample solution is a glass tube 5 millimeters in diameter. The sample-tube holder (sometimes called the probe) is situated directly between the poles of the d.c. magnet and contains the oscillator and receiver coils. The 60-megacycle-per-second radio-frequency oscillator which supplies the resonance frequency radiation, the receiver, and the oscilloscope that records the strength of the signal picked up by the receiver, are all more or less stand-



➤ THIS IS A reproduction of a chart from a nuclear magnetic resonance analysis of a sample of methyl pimarate. A partial interpretation of the significance of some of the peaks has been added.

ard, self-contained units. As already mentioned, the d.c. electromagnet is quite a powerful one and the magnetic field must not only be uniform throughout the area of the sample but must be adjustable in intensity in small steps over a wide range, and must be controlled to the extreme degree of precision of 1 part in 100,000,000. Considerable auxiliary equipment, which is too involved to describe here, is necessary for control of the magnet. This control is vital to the success of the method and utilizes some very interesting and ingenious devices.

For simplicity, mathematics have been omitted from this description of n.m.r. spectroscopy. A more detailed explanation would of necessity become highly mathematical. Contrary to what one might expect, once an investigator has developed some experience, interpreting the spectra is, in most cases, quite a simple and easy procedure. This ease of reading results is one of the advantageous characteristics of n.m.r. To extract the last

bit of information, however, one may employ a more complex mathematical interpretation.

A technique apart from n.m.r., yet similar in the basic theory involved, is electron spin resonance, e.s.r. Because the magnetic moment of an electron is much larger than that of a proton the equipment for e.s.r. investigations is different from that used for n.m.r. The kinds of problems to which the two techniques apply are also somewhat dissimilar. The e.s.r. procedure is not being dismissed with one paragraph because it is less interesting or less important than n.m.r. It just happens that we elected to tell you about n.m.r. in this story rather than to try to cover the subject of magnetic resonance broadly, including e.s.r.

Research leads one knows not where. The concept of nuclear magnetic resonance has led to a research tool which, in turn, is capable of leading chemists into all sorts of investigations not previously feasible. The paths into which all these investigations will lead have no visible end.

Cosmetic Base Detects Particles

★ A LIQUID originally designed as a base for cosmetics is proving very useful to physicists trying to detect the various particles given off by exploding atoms.

Most liquids that give off tiny light flashes, or scintillations, when bombarded by nuclear particles are hazardous if used in large volumes, as is sometimes necessary. Some of them also dissolve their Lucite container, used because it is transparent and easily shaped.

To overcome these difficulties, Drs.

H. A. Miranda, Jr. and H. Schimmel of Columbia University's Hudson Laboratories, Dobbs Ferry, N. Y., investigated other liquids for use as a scintillator. They found that Dow Corning Silicone-555 fits the requirements. It is water-clear and does not affect Lucite even after prolonged contact, they report in the Review of Scientific Instruments (Dec., 1959). The most suitable mixture is four grams of 2,5-diphenyloxazole plus 100 grams of naphthalene for each liter of Silicone-555 fluid.

Spherical Ion Accelerator

by JEROME G. SPITZNER
St. James High School, St. James, Minnesota

Jerome Spitzner, 17, was the top winner of the 19th Science Talent Search for which he will receive a \$7,500 Westinghouse scholarship.

➤ A SPHERICAL ION accelerator differs from other ion accelerators inasmuch as it does not form a beam in any one plane. The charged particles are instead free to travel in any plane which would contain an imaginary line that we shall call the axis of the accelerator. However, a defined beam can be formed by using electromagnets.

The particles are contained between two concentric spheres and are accelerated by a grid. If we remove the outer sphere, the apparatus can be compared to the earth, with the grid corresponding to a picket fence following the equator around it, the ion paths corresponding to the meridians, and the axis of the accelerator corresponding to the axis of the earth.

At one point there is a short gap in the grid. This gap is the target area, and a substance can be placed here for bombardment. A pair of electromagnets with their magnetic axis in the plane of the grid are arranged to focus the ions into a beam that will strike the target. A second pair of electromagnets, whose axes are also in the plane of the grid but rotated sixty degrees with respect to the first, can be used to form a beam which would not strike the target.

If the outer sphere is now replaced, four glass tubes can be seen, fastened to its surface and arranged so that their longitudinal axes are parallel with the axis of the accelerator and tangential to the surface of the inner sphere if extended. The elements in these tubes will be described later.

The entire accelerator is enclosed in a vacuum chamber with the outputs from the various electronic equipment necessary for its operation fed through a plug.

Theory of Operation

The accelerator is designed primarily for positive ions; consequently I shall limit my discussion to the production and acceleration of this type of ion only. The production and initial acceleration of ions takes place in the glass tubes, which are similar to positive ray tubes, having a solid anode plate at one end and a long cylindrical cathode at the other. A thin metal foil forms a cap over the cathode to prevent contamination of the chamber vacuum with gas from the tubes. Electric resistance wire is wound around the tubes to vaporize electrically solid substances that are to be subsequently ionized. The speed of the ions leaving the tubes via the



► JEROME G. SPITZNER, 17, explains his ion accelerator at an exhibition held in Washington. He built the accelerator in his laboratory, an ex-chicken house on his father's farm, out of old TV parts and equipment borrowed from his school, a nearby college, and a local radio shop, together with such unlikely objects as a float from a pig waterer and a silver-painted Christmas tree ball.

cylindrical cathode can be controlled by varying the cathode voltage. Once an ion has entered the ion chamber, the grid takes over acceleration. The spheres carry a high positive charge; therefore the ion will seek a position where the repulsive forces will be in equilibrium. If it is moving, centrifugal force will push it nearer the outer sphere.

An alternating potential is being applied to the grid by an oscillator. The ions will be attracted to it when the voltage is negative, but just as they

reach the grid, the voltage becomes positive, repelling them. Their momentum carries them through the grid, and the positive charge repels them until they are shielded from its effects by the curvature of the inner sphere. During the time that they are shielded, the grid potential will again become negative, and once more attract the ions as they come around the other side to repeat the process. Thus, two groups of ions on opposite sides of the sphere are continually moving around it, their number increasing as

more are added on every revolution, and their speed increasing as the frequency of the grid is increased.

The ions will always approach the grid at right angles. Since electrostatic attraction and repulsion varies inversely as the square of the distance, the ions will be attracted to the grid most strongly along the line of shortest distance. Because the shortest distance between two points is defined as the perpendicular, the ions will follow orbits in a plane perpendicular to the plane of the grid. Any deviation will correct itself.

Construction and Testing

The accelerator was constructed using easily available materials. The spheres, with a diameter of eight cm. and ten cm. respectively, were spun from copper. The grid was made from copper screening and insulated with polyethylene. The elements were waxed into the glass tubes and the entire accelerator assembled in a hard rubber frame which also held the electromagnets. This frame was placed inside a vacuum chamber and the elements wired through a plug. The electronic equipment consisted of a variable frequency oscillator with an output of 10 watts at 500 volts; a high voltage transformer and rectifier with five outputs, each variable from 500 to 100,000 volts; and a variable D.C. current source for the electromagnets.

After assembly and testing of the individual components, a film packet was inserted as a target and the chamber evacuated with an oil diffusion pump. Low pressure hydrogen was admitted to the tubes and the other equipment was activated. After a ten second build up, the ions were focused

on the target. The film showed a faint streak after development. Subsequent tests confirmed the existence of a beam.

Experimental Operation

It would be extremely difficult to describe in detail the experiments that I have performed with this accelerator. I shall attempt to sketch a few of them.

If the magnets are used to orient the ions into a beam and are then turned off, the ion beam will behave as an ultrasensitive gyroscope for periods of ten seconds or so, after which the mutual repulsion of the ions scatters the beam. The position of the ion beam can be determined during this time by using an internal condenser and an FM transmitter. The capacitor is used as an element of the tuning circuit of the FM transmitter. Any variations in the orientation of the beam will be reflected by a change in the capacitance and a consequential change in the frequency of the oscillator circuit. With more sensitive equipment it may someday be possible to use the accelerator as a gyroscope for longer periods of time.

A piece of aluminum may be used as a target for alpha particles. If this is done, the aluminum will afterwards emit positrons, as it is known. The interesting variation is the use of aluminum foil to cover the cathodes of the positive-ray tubes. If helium gas is ionized in the tubes, a certain number of positrons will also be produced and sent into the accelerator. I have allowed the ions to build up into an intense beam, then focused them through a magnetic field to separate the positrons and the more numerous

alpha particles. So far the beams produced have been very weak, but I feel that positrons have been evolved.

Future Applications

After I have built more detection equipment, I hope to use the positron beams to study nuclear reactions. An even more exciting possibility is the acceleration of ions in opposite directions, and the application of a strong magnetic field to cause them to collide. It may even be possible to collide ions of different masses by adjusting the speed so that their relative velocities bear a 2:1 ratio, and using a stronger magnetic field than is available at present.

Summary

I have built and successfully operated a radically new type of ion ac-

celerator. The cost to me at the present time has been less than \$35.00, if the equipment loaned to me by the St. James High School, Gustavus Adolphus college, and Sneed's Radio Service is excluded. The project has required months of planning, and is entirely original to my knowledge. I believe that new methods and techniques made possible through this machine will prove invaluable in nuclear studies.

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Steroid Partially Restores Youth

► AN APPROACH to a pharmaceutical fountain of youth has been achieved by administering androgenic steroid to aged men. A degree of restoration of youthful function, particularly of muscle, has been observed.

Dr. Gregory Pincus, research director of the Worcester Foundation for Experimental Biology, Shrewsbury, Mass., has reported that the androgen administration alone does not completely restore youthful function in elderly men but it does help bring back some youthful attributes.

The use of the steroid for the treatment of the aged men is based upon the fact that with advancing age the manufacture in the body of steroids declines.

"There may be irreversible age condition changes that cannot be corrected by the steroid treatment and there may be other hormonal deficits," Dr. Pincus suggested.

"We still have no knowledge of age-related changes in the production of other steroidal hormones such as progesterone and aldosterone. Furthermore, the effects of the steroidal hormones upon other hormone producing systems in the body such as the thyroid gland and the pituitary gland yet remain to be explored in elderly subjects.

Dr. Pincus declared that the full role of the hormones as sustainers of youthful metabolic function still remains to be determined.

American Crystallographic Association

► THE AMERICAN Crystallographic Association was formed in 1950 by merger of the Crystallographic Society of America and the American Society for X-Ray and Electron Diffraction. As expressed in its constitution the broad objective of the Association is "to promote the study of the arrangement of the atoms in matter, its causes, its nature and its consequences, and of the tools and methods used in such studies." This objective manifests as activity on both pure and applied levels not only in crystallography but also in the related fields of chemistry, mineralogy, geology, solid-state physics, biophysics, ceramics, polymers, metallurgy, etc. In addition much attention is given to the techniques of x-ray, electron, and neutron diffraction as applied to the determination of molecular and crystal structures and to more practical and analytical problems.

The current membership of nearly 900 includes some 300 academic members, 450 industrial members and 150 from various government services and independent research institutes and foundations. Traditionally the science of crystallography has not been taught in departments of crystallography but rather in departments of chemistry, mineralogy, physics, metallurgy, etc. For this reason the Association has encountered, and attempted to satisfy, a need to establish more firmly the sci-

ence of crystallography in its own right as well as to enhance the professional standing of crystallographers.

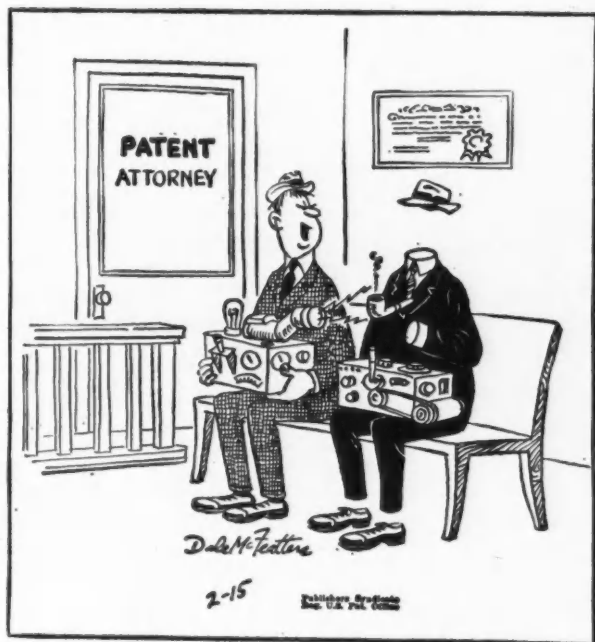
Through the media of its annual technical meetings and publications ACA has provided a stimulus for the dissemination of the results of the manifold researches of its members. This cumulative research effort has greatly contributed to our understanding of the structures of chemical molecules, both inorganic and organic. Perhaps the most conspicuous accomplishments of recent years have been in biochemistry and biophysics, including, for example, the solution of the molecular structures of penicillin and vitamin B₁ and great advances in our knowledge of the structures of the polypeptides, proteins and viruses. Parallel, although possibly less glamorous, advances have resulted from modern crystallographic investigations in such fields as mineralogy, ceramics, solid-state physics, metals and polymers.

ACA sustains a program for advancing the status and research productivity of crystallography by means of cooperative relationships with other organizations and through committee activities. In the latter category the following accomplishments may be cited: establishment of national and international standards in the design of x-ray crystallographic apparatus, publication of crystallographic monographs and

compilations of data, assistance in the development of a systematic scheme for chemical analysis by x-ray methods, and improvement of crystallographic computing methods. ACA cooperated with the International Union of Crystallography in establishing the journal *Acta Crystallographica* and regards it as its unofficial organ.

ACA is an Associate Member society of the American Institute of Physics (AIP) and cooperates closely with the International Union of Crys-

tallography in numerous ways. ACA appoints representatives to the National Research Council - National Academy of Sciences, to the AIP Advisory Board on Russian Translations and to the U. S. A. National Committee on Crystallography. As special benefits ACA members receive free subscriptions to *Physics Today* and to *Bulletin Signaletique*, the crystallographic abstracts journal published by the Centre National de la Recherche Scientifique (CNRS) of France.



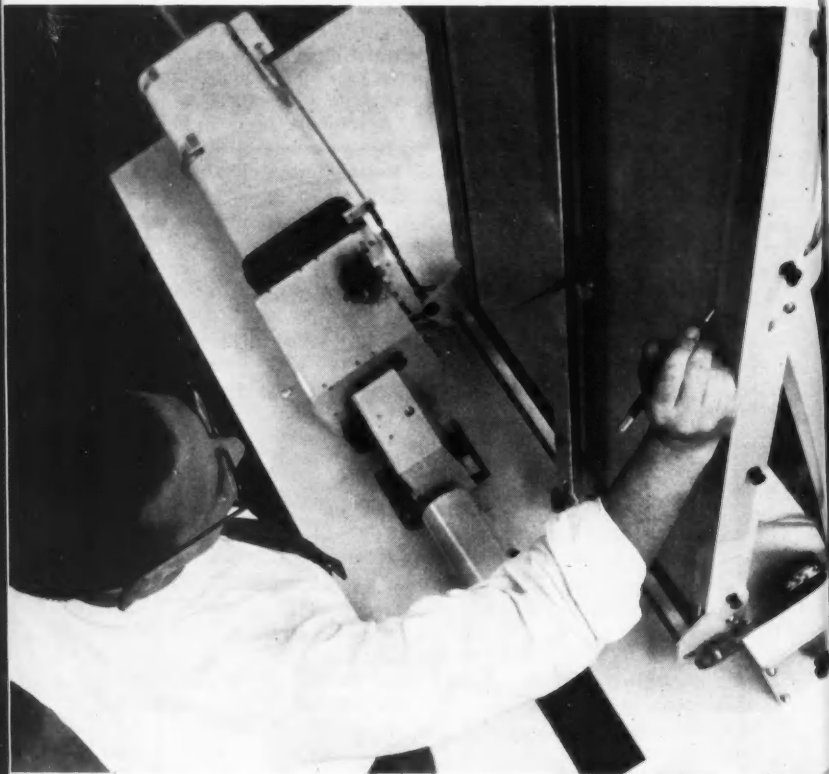
"Mine makes people invisible!"

Automatic Spectropolarimeter

➤ A NEW SPECTROPOLARIMETER at Eli Lilly and Company automatically records a curve of optical rotation for an optically active compound in only twenty minutes. On an ordinary instrument, the plotting of such a curve

requires from two to three hours.

The new automatic machine was developed by the Rudolph Instruments Engineering Company, Little Falls, New Jersey, in consultation with Max M. Marsh, of Lilly's analytical



➤ MAX M. MARSH, of the analytical research department, Eli Lilly and Company, labels a curve on the automatic recording spectropolarimeter, the first instrument of its kind.

research department. The principle of the prototype instrument was tested in the Lilly analytical laboratories as were some of its component parts.

The new instrument is being used in steroid and protein studies.

Very subtle differences of very similar compounds can be distinguished by the spectropolarimeter since even the slightest change in an optically active molecule varies the angles at which polarized light of various wave-

lengths, passing through it, is rotated.

In the new instrument, a motor gradually turns the prism of a monochromometer through the full range of light waves from a xenon arc. The polarized light is passed through a sample of compound and the angle of rotation varies with the wavelength. This light information is transformed into electrical information by a photoelectric cell, and the curve is automatically recorded on a graph.

√ Chemistry Quiz √

Directions: Mark the answer you think most nearly correct.

Answers are on page 24.

A. A *tektite* is

1. a new ceramic semiconductor containing tellurium
2. a small glassy body of meteoritic origin
3. a variation of chrysolite, commonly found in pegmatite crystals
4. commonly found in pegmatites

B. The "barn" is a unit used by

1. geneticists
2. geophysicists
3. nuclear physicists
4. physiologists

C. The Friedel-Crafts reaction

1. is of genuine importance in photosynthesis
2. is utilized in the Fischer-Tropsch process
3. results in the joining of two

organic radicals and evolution of hydrogen chloride

4. uses metallic sodium as a catalyst

D. The Feulgen reaction is used for identifying

1. DNA
2. lipid
3. protein
4. RNA

E. Which of the following is *least* related to the other three?

1. galactose
2. glucose
3. mannose
4. xylose

Complete copies (with answers and norms) of many previous Science Talent Search examinations are available at 15c each from Science Service, 1719 N St., N.W., Washington 6, D. C.

MAGNESIUM

The Lightweight Metal

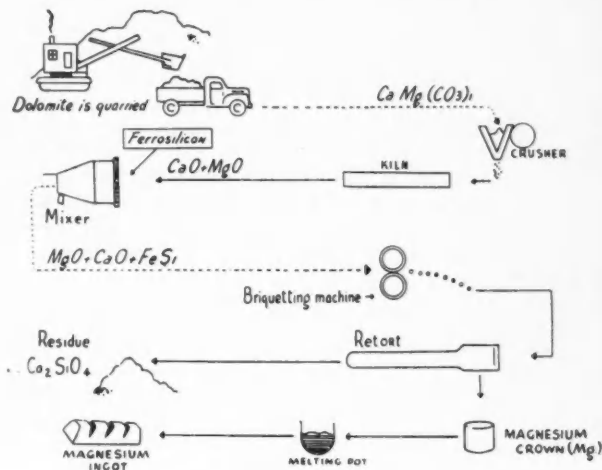
by RALPH G. GILLESPIE of Brooks & Perkins, Inc.

➤ MAGNESIUM is the lightest of all commercial metals used today. It is less than $\frac{1}{4}$ the weight of steel and only $\frac{2}{3}$ the weight of aluminum. With this lightness it also has excellent strength. For this reason it is used in airplanes, in luggage, in materials handling equipment, in electrically operated hand tools, and in hundreds of other products which must be carried or pushed. It is the metal which lightens loads and makes men's work easier.

Both the Vanguard satellites and

the Discoverer satellites are made of magnesium. The use of this lightest of metals, by reducing weight, makes possible the maximum payload in satellites and missiles. Most U. S. missiles use magnesium in many places in their structures.

Because of its light weight it is used for moving parts in band saws, textile machinery, printing machinery, radar equipment and many other places where the light weight helps to make possible extra speed. Because it withstands shock better than most

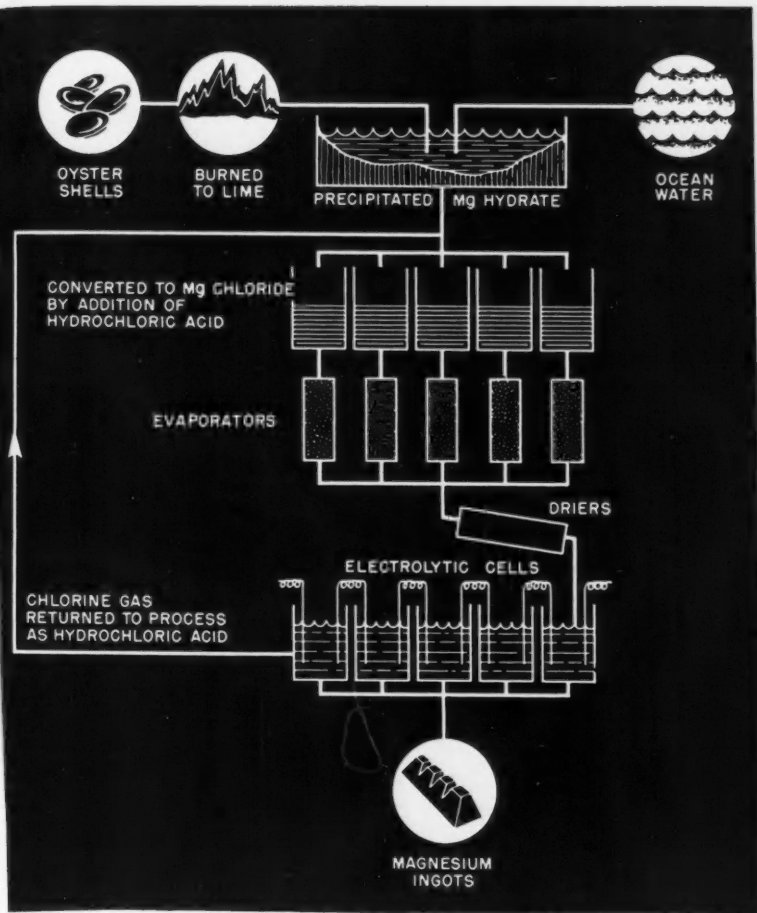


➤ THE GREATEST PROPORTION of magnesium used today is obtained from dolomite, a mineral consisting of the double carbonate of calcium and magnesium, by the ferrosilicon process.

other materials, all military airplane wheels have for many years been made of magnesium.

Magnesium is also added as an al-

loying element to aluminum and many other metals to increase their strength. It is used as a reducing agent in extracting, uranium, titanium, zir-



THE ABOVE FLOW-CHART shows diagrammatically the electrolytic process for the extraction of magnesium from sea water.

conium, beryllium and other metals from their ores. Without magnesium we might not have volume production of these other useful metals.

An important use of magnesium is based on its ability to protect steel from rusting. It is used on the hulls of our big ocean-going steamships and in the tanks of tankers to prevent rusting away of the ships. It is used in our home water heater tanks and with cross-country pipelines for the same purpose.

Magnesium is the most widely available metal in the world on the basis of available supplies of useable raw materials. It is extracted both from sea water and from dolomite ore. Both of these materials are available in almost unlimited quantity.

If all the magnesium in the sea was to be extracted today it would cover the earth's land area to a depth of six feet. Taking a year's supply of magnesium from the ocean is like taking a bottle of mist from a London fog, for in one cubic mile of sea water there is 11,500,000,000 pounds of magnesium, more than 30 times the amount used in the peak war year of 1943. But that is only a part of the story; in addition, dolomite and mag-

nesite deposits, a source of magnesium quite as good as sea water, are to be found practically anywhere on the earth's surface. Actually, magnesium is the sixth most plentiful metal in the earth's surface. Different from most metals, it is widely distributed and easily recovered.

Supplies will never be exhausted. This means that more and more magnesium will be used as other metals become scarce or higher priced due to costs of transporting the high grade ores longer distances, or to high-cost processing of low grade ores.

When sea water is used as a source of magnesium the metal is separated by the use of electric current (electrolysis) from magnesium chloride as shown in the process flow chart. This is the process used by The Dow Chemical Co. at Freeport, Texas.

When dolomite or magnesite is used the process is carried on under a high vacuum. A mixture of dolomite, silicon and iron (ferrosilicon) is reduced to magnesium and a residue slag as shown in the chart. This process is used by The Alabama Metallurgical Corporation at Selma, Alabama and by the government-owned plant at Caanan, Connecticut.

New Device Detects Nuclear Particles

► A NEW KIND of device for detecting the particles given off by exploding atoms was reported to the American Physical Society meeting in Pasadena, California.

Semiconductors, the materials that make transistors possible are used in the new particle detectors, Dr. J. W. Mayer of Hughes Aircraft Company, Los Angeles, said. The devices can

be made small enough to fit into a hypodermic needle or other little instruments.

Dr. Mayer reported that the "solid state ionization chamber," as it is called by physicists, is in use for detecting protons, deuterons (the nuclei of heavy hydrogen), helium three, alpha particles and the fragments produced when uranium fissions.

New Chemical Patents

To obtain copies of these new patents, order them by number from the Commissioner of Patents, Washington 25, D. C. Enclose 25 cents in coin, money order or Patent Office Coupons (but not stamps) for each patent ordered.

Flavor Restored in Processed Foods

► CANNED, frozen and dehydrated foods may be made to taste like fresh foods by a new flavor-enhancing method that uses flavor enzymes obtained from bruised fruit and other food wastes.

The radical method is expected by its developer, the Evans Research and Development Corporation, New York, to have far-reaching effects on the nation's \$55 billion food processing industry.

Commercial applications of the new process, it says, might be in the actual processing or packaging of the food, or as a shaker-type powder that could be merchandised at the retail level.

The process, granted patent No. 2,924,521, is based on research into the chemical nature of flavor. Fresh flavor is produced by the catalytic action of specific enzymes on chemical compounds in natural foods called "flavor precursors."

Usual methods of processing inactivate substantially all the enzymes, including those responsible for flavor. The flavor precursors are more stable, however, and ordinarily survive this operation. They regenerate fresh flavor when the specific enzymes are restored.

These flavor enzymes are obtained from the fresh food or biologically re-

lated materials. The source may even be waste products such as bruised or overripe fruit, or inedible parts such as stalks, leaves or skin.

Invented by Drs. Eric J. Hewitt, Donald A. M. Mackay and Kurt S. Konigsbacher of Evans Research and Dr. Torsten Hasselstrom of the Army Quartermaster Research and Engineering Command, the process applies to a wide variety of canned, frozen, dehydrated or irradiated foods. These include string beans, cabbage, horseradish, bananas, blueberries, milk, meat and fish.

Dr. Murray Berdick, coordinator of research at Evans, speculates that flavor-improved dehydrated foods may well revolutionize food merchandising. Eventually, he says, all kinds of dehydrated foods may be purchased out of the pages of mail order catalogues.

Dr. Berdick also prophesies that the U. S. astronauts will have a flavor-enzyme kit to prepare in space a "home-cooked" meal that has a fresh-cooked flavor.

H-Bomb Power May Be Nearer

► A NEW DEVICE may help American scientists learn how to control the awesome power of the hydrogen bomb.

A high-energy gaseous discharge de-

vice has won patent No. 2,925,512 for Vernal Josephson of Palos Verdes Estates, Calif., who developed it while working at the Los Alamos, N.M., laboratories of the Atomic Energy Commission, to which the patent was assigned.

The invention is an improved magnetic pinch device for use in studies on the fusion process that gives the H-bomb its tremendous power. Actual fusion has never been produced in the laboratory with this device, however.

Made of metal, the device resembles a tin can. It has a peephole through which the brilliant flash inside can be seen when an electric current is discharged through a plasma. Running from one electrode to the other inside the "can" is a cylinder formed of two current-carrying coils that set up a magnetic field. This field prevents the pinch effect from deteriorating during the brief flash.

In contrast to earlier such tubes made of quartz, ceramic, porcelain or glass, the new tool is reusable and does not pollute the plasma with impurities under the intense heats generated. It has been found that this device enables the plasma to conduct more quickly, and gives more consistent results than its forerunners.

Pressure Measured by Light Scattering

► WITH AN OPTICAL DEVICE invented by Marvin N. Silver of New York City (No. 2,925,007), scientists can

look into closed vessels and instantly determine the gas pressure inside down to very low levels. Free of pipe connections to the container, the optical device works on the principle that a beam of light is scattered by gas molecules. A light-sensitive detector measures the amount of light scattered from a beam projected into the container. The patent was assigned to Tung-Sol Electric Inc., Newark, N. J.

Meats Improved by Mold and Bacteria

► AN ILLINOIS INVENTOR has been awarded two patents for improved methods of tendering and flavoring meat. Beverly E. Williams of La Grange Park assigned patent rights to both methods to Hodges Research and Development Co., New York.

One method, patent No. 2,926,089, uses a class of molds called *Thamnidium*; the other, patent No. 2,926,090, uses two families of bacteria known as *Pseudomonas* and *Achromobacter*. In both processes, the inventor claims, the treated beef is properly aged, ripened and improved in tenderness and flavor within about 48 hours.

Tests comparing both methods with present commercially acceptable practices show that the new methods result in 10% to 20% more tender and better flavored U. S. Choice beef, 20% to 40% better U. S. Good beef, 30% to 50% better U. S. Commercial beef, and 40% to 50% better U. S. Utility beef, the inventor states.

Answers to CHEMISTRY QUIZ on Page 19.

A - 2; B - 3; C - 2; D - 1; E - 4.

For the Home Lab

Tartaric Acid

by BURTON L. HAWK

► TARTARIC ACID is widely distributed in many fruits, particularly grapes. The deposit formed in wine casks during the fermentation of grape juice contains potassium acid tartrate and it is from this deposit, which is called *argol*, that tartaric acid and its compounds are obtained.

Actually, there exist four tartaric acids: *d*-tartaric acid, *dl*-tartaric acid (racemic acid), *l*-tartaric acid, and mesotartaric acid. Although the composition is the same, these compounds differ in molecular arrangement. The *d*-tartaric acid is the common material, although racemic acid is also found in nature. Mesotartaric acid is formed, along with racemic acid, when the *d* or *l*-tartaric acid is heated with water for a long period of time or by boiling a solution of sodium tartrate with sodium hydroxide.

Reactions

Prepare a solution of tartaric acid by dissolving 1 gram in 80 cc. of water. To about 10 cc. of this solution, add one drop of ferric chloride solution. Note carefully the shade of the color. It should be slightly more yellow than the color of ferric chloride solution. This is a sensitive test for α -hydroxy acids.

Place a small quantity of tartaric acid in a dry hard-glass test tube. Heat gently, gradually increasing. Note the material first melts then finally chars with evolution of heavy acid vapors.

Place one cc. of concentrated sulfur-

ic acid in a test tube. Add a few crystals of β -naphthol and then a few crystals of tartaric acid. Heat the tube carefully, keeping your face away. The solution is colored blue which rapidly changes to a beautiful emerald green on continued heating. Now pour the solution into a large quantity of water (careful!). It will dissolve forming an anemic yellow-orange solution.

For variation, repeat the above test using resorcinol instead of the β -naphthol. This time a deep rich red color is obtained. This again dissolves in water to form a pale yellow-orange solution.

Add cobalt nitrate to a solution of tartaric acid. A light red color develops. Add sodium hydroxide solution and the color disappears. Heat to boiling and the solution turns blue. Upon cooling, it becomes colorless.

Compounds

Calcium Tartrate. Calcium tartrate is only slightly soluble in water. To prepare it, first neutralize a solution of tartaric acid with ammonia. Then add a solution of calcium chloride. Usually the precipitate of calcium tartrate is slow in forming. If it does not appear, rub a glass rod against the tube under the surface of the liquid. If this does not work, shake the solution vigorously for a few minutes. Calcium tartrate should eventually precipitate out; it just needs persuasion.

Cream of Tartar. This popular compound is usually found in the kitchen. It is used in cooking and baking, and it is also a component of some baking powders. Prepare a concentrated solution of tartaric acid by shaking the compound with water until no more dissolves. Allow the undissolved portion to settle, then carefully pour off the clear liquid into another tube. Now, slowly add a 10% solution of potassium hydroxide, drop by drop, until a crystalline precipitate forms. The material will quickly settle to the bottom of the tube in the form of fine crystals. This is potassium acid tartrate, more commonly known as cream of tartar. It is only moderately soluble in water. If potassium hydroxide solution be added in excess, the precipitate will dissolve as the more soluble potassium tartrate is formed.

Rochelle Salt. This material may be found in the medicine chest, as it has been used as a saline cathartic for many years. Amateur radio hobbyists will be familiar with it wherever piezoelectric crystals are used; Rochelle salt crystals have been used to control radio frequencies. But, to the chemist its most familiar use is as a component of the famous Fehling's solution. It is useful here because it dissolves the copper hydroxide precipitated when the two parts of the Fehling's Solution are mixed. Add 1 cc. of copper sulfate solution to 5 cc. of sodium hydroxide solution. Now add a solution of Rochelle salt and note the precipitate is dissolved. (Be sure a large excess of sodium hydroxide is used). Of course, Rochelle salt is not the only substance that will dissolve copper hydroxide. Repeat the above using glycerine in place of the Rochelle salt.

The chemical name for Rochelle salt is potassium sodium tartrate.

Fenton's Reagent. To a solution of tartaric acid or Rochelle salt, add one drop of freshly prepared ferrous sulfate solution and 2 drops of fresh hydrogen peroxide. Stir, then add an excess of sodium hydroxide solution. An intense violet coloration is formed. The formation of the violet Fenton's Reagent serves as a test for tartrates or tartaric acid.

Silver Tartrate. Add a solution of silver nitrate to a solution of Rochelle salt. A white precipitate of silver tartrate is formed. Now add ammonium hydroxide, in small quantities, until the precipitate is just dissolved. Now carefully drop an additional crystal of silver nitrate in the solution and warm gently. A silver mirror is deposited on the sides of the tube.

Tartar Emetic. This substance, antimony potassium tartrate, is used in medicine as an emetic and as a mordant in dyeing. To prepare it, dissolve 2 grams of potassium bitartrate (cream of tartar) in 20 cc. of water, heating if necessary. Add $\frac{1}{2}$ gram of antimony trioxide and continue to boil for 3 minutes. Filter. Evaporate the filtrate to about one-third its original volume. Allow it to stand. After a while crystals of tartar emetic will separate out.

Seidlitz Powders. This material, used as a laxative, is usually supplied in two wrappers. The white wrapper contains tartaric acid. The blue wrapper contains a mixture of Rochelle salt and sodium bicarbonate. The solutions of the contents of these wrappers are made separately. When mixed, the carbon dioxide evolved masks the unpleasant tastes of the chemicals.

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Announcing new developments in the chemical industry and newly available chemical literature.

New Method for Epoxy Coatings by Formulators

► A NEW METHOD for the production of epoxy ester coatings, was disclosed by Union Carbide Plastics Company at the 1959 Paint Industries Show, Atlantic City. It is expected to be of great interest to manufacturers of varnishes and other coatings based on epoxy resin esters.

Production of this important class of epoxy coatings has been limited to the use of esterification grade solid epoxy resins of which only relatively few are available. The coatings manufacturer has had no direct control of the molecular weight or length of the polymer chain but only of choice of acid and degree of esterification.

Using only a liquid epoxy, ERL-2774, bisphenol A and any drying acid, the formulator now can prepare, in two simple steps, a varnish with preselected properties. The method, developed in the research department of Union Carbide Plastics Company, Division of Union Carbide Corporation, yields products equal or superior to similar ones prepared from drying acids and esterification-grade solid epoxy resins. In addition, products of much greater average molecular weight can be made.

Basis for the new technique is the preferential reaction of the epoxy group with carboxyl groups before reacting with aromatic hydroxyl groups in a mixture where all three are present. By proper proportioning, ERL-

2774, bisphenol A and a fatty acid can be reacted to produce an essentially linear epoxy of any desired chain length, terminated at each end by a fatty acid group. This intermediate compound is then further reacted with fatty acids to produce the desired degree of esterification.

Versatility of the method is pointed up by the preparation of rapid drying varnishes from resins esterified with semi-drying acids. The relatively poor drying effect of the latter is compensated for by increasing, at will, the degree of polymerization of the initial condensate. Further use of the technique is demonstrated in the variety of completely different chemically-modified epoxy compounds that can be produced. The coatings formulator and varnish maker will be afforded very wide opportunities in tailor-making epoxy resin products for special applications.

Thermoplastic Delrin Now Available

► DELRIN ACETAL RESIN, a new thermoplastic material developed by duPont, is currently being made available in extruded rods up to three inches in diameter by the United States Gasket Company, Plastics Division of The Garlock Packing Company. The new material has outstanding tensile strength, rigidity, fatigue life and resistance to creep and solvents at both room and elevated temperatures. These properties are com-

bined with Delrin's excellent dimensional stability, and good electrical and frictional properties.

Delrin rods have a hard glossy surface with a very low coefficient of friction, thus eliminating slip-stick, a problem in some applications involving friction. They also possess exceptional dimensional stability, good abrasion resistance, and a higher fatigue endurance limit than that obtained with any typical thermoplastic under similar conditions.

Delrin combines excellent electrical properties with exceptional mechanical characteristics. It has a remarkably low dissipation factor and dielectric constant over a wide range of frequencies at normal and elevated temperatures. Its low moisture absorption and low permeability add to its ability to maintain good electrical properties even under high humidity exposure and after complete immersion in water.

There is no common organic solvents for Delrin at room temperatures, as it is one of the most solvent-resistant organic compounds known. Delrin is easily machined (similar to free cutting brass) on standard machine shop equipment by sawing, milling, turning, drilling, reaming, shaping, threading and tapping. At low speeds no coolant or lubricant is necessary. Delrin can be blanked and punched to produce smooth, flat parts such as washers, grommets, actuator cams, and non-precision gears.

New Edition of Chemical Classic Announced

► CORNELL UNIVERSITY PRESS announces publication of the third edition of a book universally recognized

as the authoritative work in its field, "The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry," by Linus Pauling, who won a Nobel Prize in chemistry in 1954 for his work in this area.

"The Nature of the Chemical Bond" was originally based on a series of lectures delivered at Cornell, in the fall semester of 1937-1938 when its author held the George Fisher Baker Non-resident Lectureship in Chemistry. The first edition was published in 1939, and the second in 1940. The third edition brings the material up to date with additions based on recent research.

Dr. Pauling describes his book as providing a general treatment, essentially nonmathematical, of present knowledge about the structure of molecules and crystals and the nature of the chemical bond.

Included in the new material in the third edition are a detailed resonating-valence-bond theory of electron-deficient substances, a chemical theory of the structure of metals and alloys, a discussion of the role of the hydrogen bond in the structures of proteins and nucleic acids, the electroneutrality principle, and other new principles of molecular structure.

New Brochure on Molecular Sieves

► A NEW 12-PAGE brochure on the availability and uses of Linde Molecular Sieves has been published by Linde Company, Division of Union Carbide Corporation. Linde Molecular Sieves are synthetic zeolites, each crystal of which contains a small cavity of controlled angstrom-range size that can

be pre-loaded with a chemical for release at a determined time during a chemical process.

Entitled "Chemical-Loaded Molecular Sieves in Rubber and Plastics," the brochure discusses the general properties of the product, with emphasis on its uses in latent curing and such factors as release temperatures versus volatility.

There is a section on testing Molecular Sieves for determining performance. Methods of handling Chemical-Loaded Molecular Sieves are described. And the final portion of the brochure lists the types of chemicals that are presently available in Chemical-Loaded Molecular Sieves.

Copies of the brochure may be obtained by writing to Linde Company at 30 East 42nd Street, New York 17, New York. In the United States the Chemical-Loaded Molecular Sieves for rubber and plastics use are marketed by Harwick Standard Chemical Company, 60 S. Seiberling St., Akron 5, Ohio.

Plastics Standardized in French, Russian, and English

► FINAL WORK has been done on an international standard which lists 800 equivalent plastics terms in English, French and Russian, and its approval and publication by the International Organization for Standardization (ISO) is expected soon. This is one of a number of international standards in the field of plastics being considered by the member nations of the International Organization for Standardization (ISO). These draft standards cover various test methods for determining properties of plastics.

They were prepared by the ISO technical committee on plastics, ISO/TC 61, which met in Munich, October 26 to 31, 1959. Present were 112 delegates from 18 countries.

Three new and one revised Draft ISO Recommendations were approved by the committee at Munich. These drafts will now be submitted to all of the ISO member countries for their approval. They are determination of the Vicat softening point; determination of the viscosity number of polyamide resins in solution; determination of the acetone soluble matter of phenolic moulding materials; determination of the thermal stability of polyvinyl chloride and related copolymers and their compounds by the discoloration method.

Out on letter ballot to ISO members are: method of test for tensile properties of plastics; determination of the maximum temperature and the time taken for temperature to rise during the setting of unsaturated polyester resins; determination of stiffness properties of plastics as a function of temperature by means of a torsion test; resistance of plastics to natural light; determination of changes in mechanical properties after contact with chemical substances; and resistance of plastics to artificial light.

Eight ISO Recommendations for plastics have already been published, and another 14 are in final approval stages.

The International Organization for Standardization is the world's clearinghouse for international standards. Through ISO the national standards bodies of 41 nations coordinate their standards in the interest of improving international trade.

New Armour Booklet on Cationic Chemicals

► PUBLICATION of a new booklet on cationic chemicals as conditioners for hygroscopic salts and fertilizers is announced by the Armour Industrial Chemical Company.

The booklet covers nine Armour chemicals and new formulations used for conditioning fertilizers and salts, gives methods of application and recommended uses.

Examples of the effects of conditioners on various single minerals and fertilizer blends are shown graphically. In addition, flow diagrams depict application of reagents under pilot plant conditions.

Detailed results of extensive tests and full-scale plant operations with granulated and pelletized fertilizers are included.

Copies of the booklet may be obtained by writing Armour Industrial Chemical Company, 110 N. Wacker Drive, Chicago 6, Ill.

First Maleic Anhydride Plant for West

► CONSTRUCTION of a multi-million dollar plant for the manufacture of the chemical maleic anhydride has been started at the Richmond Refinery of Standard Oil Company of California. The twenty million pound-per-year installation is being built by Badger Manufacturing Company of Cambridge, Massachusetts, for Oronite Chemical Company, a Standard subsidiary. Completion is scheduled for mid-1960.

Maleic anhydride is a chemical intermediate widely employed in production of plastics for boats, auto bodies and household appliances; high

grade paints; textile wetting agents and agricultural chemicals. The new plant is the first such installation in the West.

New Ketones Data Published

► A NEW 48-page booklet describing ketones as solvents and chemical intermediates has been published by Union Carbide Chemicals Company, division of Union Carbide Corporation.

The booklet has up-dated data on fifteen ketones and diketones that are available in commercial quantities from Carbide. It includes information on applications, coatings, formulations, physical properties, solvent properties, constant-boiling mixtures, shipping, storage, handling, physiological properties, specification limits, and test methods. A comprehensive bibliography on ketones and their uses is a feature of the new publication.

Ketones are widely used by the surface coatings industry as solvents for nitrocellulose and other cellulose esters, vinyl-chloride-acetate, and other resins both synthetic and natural. They are also used as dewaxing agents for lubricating oils, as solvents for pharmaceuticals, and as intermediates for the synthesis of dyes, surfactants, pharmaceuticals, lubricating oil additives, resins, and rubber chemicals.

Cosden Plans Styrene Expansion

► COSDEN PETROLEUM Corporation plans to construct facilities to triple its styrene capacity. Styrene is an important chemical building block for synthetic rubber and plastics.

The multi-million-dollar project, including two major process units, will

expand Cosden's styrene capacity to 60,000,000 pounds annually when completed late this year.

Contract for the design, engineering and construction of the entire project, which includes additional facilities for styrene monomer production and this country's first Alkar Unit, has been awarded to Badger Manufacturing Company, Cambridge, Massachusetts. This brings together again the two-company team that created Cosden's first styrene production unit. This was the "Styrene from Gasoline" plant completed in February, 1957. It is recognized today in the process industries as a unique contribution. Cosden is licensing the process throughout the world.

The additional ethylbenzene required for the styrene unit will be furnished by the Alkar Unit. This will utilize Universal Oil Product Company's process for ethylbenzene manufacture through catalytic alkylation of benzene with ethylene. Ethylbenzene is the precursor for styrene. Since all of the ethylbenzene available at Cosden's Big Spring Refinery is presently being recovered and converted to styrene, this expansion program required a new source. UOP's Alkar was the answer.

The Alkar process, announced by UOP last May, uses a fixed bed catalyst system that gives complete conversion of low purity ethylene found in the residue gas of a cracking unit. Benzene will be supplied from Cosden's BTX Unit, which was its first petrochemical venture in 1952.

Since June 1958, when the Polystyrene Unit went into operation, Cosden has been supplying molding compounds to the plastics industry. A

unique distribution system was introduced in which the polystyrene in pellet form is shipped directly to the customer's plant in bulk trailers or rail hopper cars. A pneumatic unloading system quickly discharges the product into the customer's bins where it can be conveyed directly to the molding machines.

New Monthly Chemical Index Announced

► INDEX CHEMICUS, a monthly index to 50,000 new chemicals reported each year in the scientific literature will be published by Eugene Garfield Associates, Philadelphia. Inaugural issue will appear early in 1960.

New chemical compounds will be reported within 30 days after original publication in the scientific literature. Existing indexes appear two to four years behind original publication dates and the time lag has been increasing. Elimination of the time lag has been accomplished through the development of new indexing techniques, utilizing unique manual and machine methods for handling scientific information.

Index Chemicus will contain listings of chemical names, structural diagrams, and molecular formulas as well as complete bibliographical information including article title, authors, institutions, addresses, and original journal references and page locations for each compound. In addition, indexes will be cumulated monthly, quarterly, and yearly.

The techniques to be used in compiling this index were developed by Garfield Associates as a by-product of a steroid coding project performed for the Pharmaceutical Manufacturers

Assn. and the U. S. Patent Office for the past two years.

For further information, contact Eugene Garfield Associates, 1122 Spring Garden Street, Philadelphia 23, Pa.

Formaldehyde Stabilized By New Process

► CELANESE Chemical Company has developed a new process for stabilizing formaldehyde that makes it possible to reduce storage temperature by 15° to 20° F.

Advantages offered by Celanese's stabilized formaldehyde: it lessens the chance of precipitation, thus enabling customers to order higher concentrations; it maintains higher clarity, reduces acidity and lowers costs by reducing storage temperature requirements; and in some cases it eliminates the need for methanol inhibitor.

Formaldehyde, shipped and stored in insulated steam-heated tank cars and tanks, is most commonly sold in 37% aqueous solutions. To prevent precipitation of solid paraform in these solutions, they must be stored at a minimum temperature of 90° F. An inhibited grade, containing 7% methanol, must be stored at about 70° F. Use of higher concentration solutions, up to 44% without methanol, has not progressed to a marked extent because they require up to 120° F temperatures during transportation and storage. The new Celanese stabilized 37% uninhibited formaldehyde can be stored at 60° F and in 44% concentration at 100° F.

Formaldehyde is one of the biggest-volume chemicals in use today. Its main use is as an intermediate in the manufacture of phenolic, urea and

melamine resins, which find application in a variety of markets such as plywoods and furniture glues, textile finishes, automotive and metal finishes, plastics and numerous other fields.

Seven New Products At Paint Show

► UNION CARBIDE Plastics Company at the 1959 Paint Industries Show, Atlantic City, introduced seven new products for coatings formulation. The vinyls predominated with a plastisol primer base for improved adhesion, two vinyl copolymers with high tolerance for aromatic solvents and usable at high solids content, and a new vinyl acrylic latex with greater water-spot resistance and superior scrubability. The fast filming latex announced at the 1958 Paint Industries Show has attained rapid acceptance and is now available in commercial quantities for the production of gloss and semi-gloss coatings. In addition, a plastisol blending resin with improved heat stability was offered; mixed with conventional dispersion resins, the new material decreases plasticizer requirements.

In the epoxy field, two new resins differing in epoxy functionality were recommended for coating products by the fluidized bed coating technique.

Newly developed techniques were revealed, utilizing liquid epoxy resins, one for spray coating with 100% reactive two-component systems, the other, a simple varnish cooking technique for producing an unlimited series of ester resins of predetermined molecular weight.

The new resins are available to coatings formulators in developmental quantities.

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► **DR. CHESTER M. WHITE**, who heads the anti-freeze laboratories of Olin Mathieson Chemical Corporation, is shown as he tests aluminum and other metal strips for corrosion after submersion in a new formula anti-freeze. The new formula was developed in anticipation of more aluminum parts in car engines.

New Anti-Freeze Fights Corrosion

► A NEW ANTI-FREEZE that will not corrode aluminum or other metal engine parts has been developed by Olin Mathieson Chemical Corporation.

Development work on the new formula anti-freeze was completed more than a year ago in Olin Mathieson's laboratories in Niagara Falls, and the product has been undergoing rigid tests ever since. It was developed in anticipation of wider use of aluminum

in automobile engines. Many 1960 cars have the metal in various engine parts, including cylinder blocks, cylinder heads, radiator cores, water jackets, water outlet housings and water pump parts.

Dr. Chester M. White, who heads Olin Mathieson's anti-freeze testing laboratories, said one of the problems in developing the new formula involved the development of a better

corrosion inhibitor system. This in turn involved a correctly balanced formula.

The correct balance of the new formula, Dr. White explained, results in an improved ethylene glycol anti-

freeze harmless to non-metallic parts and non-corrosive to all metals.

The new anti-freeze is non-evaporating and suitable for any type engine that uses a liquid coolant.

It will carry the corporation's anti-freeze trade name of Permanent Pyro.

Underwater Spark Shapes Metals

► IN A CRACKLE of electricity, a flash of fire and a clap of man-made thunder, a small disk of metal is suddenly "exploded" into a new shape.

The job is done underwater with high precision, according to Adolph Kastelowitz, director of manufacturing research for Republic Aviation Corporation, Farmingdale, N. Y.

Small sheets of metal $\frac{1}{16}$ th inch thick already have been shaped experimentally in the laboratory. Researchers now are working on a more powerful experimental version of this electrical metal-shaping device for heavier metal operations.

By charging storage condensers to 20,000 volts, then discharging this power between two underwater electrodes, scientists make a spark that generates a powerful shock wave in the water. The shock wave blasts the metal into the shape of the die upon which it rests.

Mr. Kastelowitz said the system promises to be useful in working some newer steel and titanium alloys that require heavy, complicated equipment to shape them into the close tolerances and aerodynamic smoothness needed.

From the U. S. Naval Ordnance Test Station at China Lake, Calif., Edward W. LaRocca and John Pearson report that they have been able to "explode" powdered titanium into simple metal objects using conventional explosives, rather than electricity.

The powdered titanium is put in a small die. The powder is rammed into a solid piece by a piston. A small explosive charge is used to shove the piston fast and hard into the powdered metal.

The forces appear to be so great that metals can be bonded by this method when they cannot by normal rolling methods. Also, it appears possible to bond dissimilar materials.

Space Saucer Could Fly on Sunlight

► A THIN, FLAT, spinning saucer made of aluminum-coated plastic membranes may be the space exploration vehicle of the future. It would run on sunlight.

Dr. Theodore Cotter, University of

Michigan physicist, told the Institute of the Aeronautical Sciences meeting in New York that this device appears to be "an extremely promising concept for space propulsion."

Dr. Cotter said there are no major

technical obstacles to an early trial of such a device.

The first step would be to launch a small saucer of 600 feet to 900 feet in diameter as an experiment to test the idea. It would be instrumented, but carry no passengers. If it proved itself, a bigger one later could be used to carry passengers on space trips without using any fuel other than the pressure exerted by sunlight and the pull of the sun's gravity.

By adjusting its angle with respect to the sun, the saucer could mix the push of sunlight with the pull of the sun's gravity so that it could go in any desired direction in the solar system.

Dr. Cotter said a saucer big enough

to carry a man in its passenger pod, deep within, would probably measure more than 1,300 feet in diameter. Its useful payload, including a man, would be about 1,000 pounds.

The space saucer would have to be launched into orbit by a conventional rocket. But once in an earth orbit, it could adjust its angle to spiral slowly away from earth on a space mission, then later return to its earth orbit.

An immediate application of the idea, Dr. Cotter said, might be to equip conventional earth satellites with smaller versions of this "solar sail." These sails could be used to make small or large changes in the satellite's orbit without help of rockets.

Emergency Blood From Seaweed

► A SEAWEED compound mixed with water can substitute for whole blood in transfusions, according to two Japanese surgeons.

Solutions of the gelatin-like substance which comes from the cells of the giant brown seaweed have been successfully used in 102 abdominal operations, they reported in the issue of the *Journal of the International College of Surgeons* (Dec., 1959).

The use of "alginon," as the compound is called, is based largely on earlier research with another seaweed derivative called "algin" from sodium alginate. Both compounds have been tested as whole blood substitutes because they are made up of large protein molecules or polymers. Like natural blood plasma, solutions of the seaweed compounds stay inside the blood vessels, keeping blood pressure

from dropping to dangerous levels.

The new seaweed compound alginon does not damage the spleen, nor does it cause hemorrhages in the skin, reported Drs. Masanobu Tomoda and Kyoshi Inokuchi of the Kyushu University Medical School, Fukuoka, Japan.

In tests with rabbits that had suffered bad burns or had lost a lot of blood, both shock conditions, no harmful changes in physiological processes were detected. Autopsies showed no effects on spleen, liver, kidney, adrenal gland, lung or brain tissues.

Furthermore, 70% of the alginon was excreted within 24 hours, indicating that "alginon has a proper period of retention in the blood without depositing itself in tissue," Drs. Tomoda and Inokuchi said. It is better than the sugar- or salt-water solutions

sometimes used in emergency transfusions because it is chemically stable, it improves the blood's ability to coagulate, and it does not dilute the capillary blood so that few red cells reach the tissues of extremities such as fingers or toes.

Unlike earlier versions of sodium

alginate, this seaweed compound is said to cause virtually no harm.

"Of a total of 477 cases there was a fever in 0.8%; chills occurred in 0.8%, and other complications were almost negligible," the Japanese surgeons said. No skin hemorrhages were found.

Mars and Venus May Have Van Allen Belts

► SUBSTANTIAL belts of trapped radiation such as found around earth may also surround Mars and Venus.

This is the conclusion of Dr. James A. Van Allen of the State University of Iowa, who discovered earth's regions of intense radiation that may prove hazardous to future space travelers. From information gathered by Pioneer IV, which is now in orbit around the sun, and from previous data, Dr. Van Allen has found that magnetic trapping of charged particles near planets is probably quite common.

He believes that it is quite common for neutrons produced by cosmic ray bombardment to move outward from the atmospheres or solid surfaces of

planets, as they are believed to do from earth, to form an inner radiation belt. Also, all bodies of the solar system are bombarded by clouds of radiation thrown out by the sun. This is the radiation believed responsible for the earth's outer radiation belt.

Dr. Van Allen concluded that both of these two important sources of trapped radiation are present throughout the solar system. The greater the magnetic moment and the less extended the atmosphere, the more favorable are conditions for a high intensity of trapped radiation.

Dr. Van Allen's report was issued in the IGY Bulletin (Dec.), a publication of the National Academy of Sciences.

Antibiotics Help Preserve Stock Feed

► "GOOD QUALITY, odor, and acidity," together with increased flavor appeal and resistance to spoilage through fermentation, may be imparted to silage, or cold weather fodder for cattle, by treatment with an antibiotic called zinc bacitracin. Dr. L. L. Rusoff of Louisiana State University reported before the American Chemical Society's Southwest Regional meeting.

Preservatives presently in use, such as molasses or sodium bisulfite, ward off spoilage by promoting the growth of acid-forming bacteria, since good silage production depends on a good acid environment, according to Dr. Rusoff. Zinc bacitracin apparently works by "inhibiting the protein splitting bacteria and favoring the lactic acid producing bacteria," he said.

The Tailored Molecule

by ALLEN LONG

The secret to finding "wonder" materials for future rockets, TV sets and automobiles rests in a new science — Molecular Engineering. Dramatic breakthroughs, already achieved, seem to promise that scientists some day will be able to engineer any material they need.

► SOME DAY scientists will be able to design with engineering precision the new materials needed to perform under special sets of conditions.

When they are able to do this, the hit-or-miss approach can be abandoned and one of the biggest and most costly bottlenecks to the advancement of scientific accomplishments will have been eliminated.

This has to come, for there are no holes in the periodic table of elements. This means that the "wonder" materials for future automobiles, wall TV sets and rocket ships must be made out of the basic substances we now have at hand.

The process of designing a new material to fit a special purpose might well be called "molecular engineering." It will include manipulating the molecular structures of known substances to build in the qualities needed.

Great strides in this direction already have been made. An end-product in one case is familiar to every person who owns a pocket-sized radio. It is the transistor — the tiny, rugged, chunk of germanium that has replaced vacuum tubes in many jobs, especially in hearing aids.

Transistors work because the germanium contains a tiny amount of an impurity. The impurity may be as little as a few atoms of indium in a mil-

lion atoms of germanium. Other impurities such as phosphorus, arsenic and antimony can be successfully used.

Pure germanium is a poor conductor of electricity. It has no free electrons. Each germanium atom has four electrons that seek to bond other atoms to it. In pure germanium, each atom successfully makes four electrical bonds with other atoms. No electrons are left over.

If germanium is to conduct electricity, it must have some free electrons. These are made available by adding tiny amounts of such "impurities" as indium, having three electrons for bonding, or phosphorus, arsenic and antimony, having five electrons for bonding.

Thus when a germanium atom combines with one of those "impurities," either the germanium has an electron left over, as in the case of a union with indium, or the impurity has an electron left over. These left-over electrons are free to move through the substance when a voltage is applied. Thus by adding an impurity to pure germanium, scientists changed a poor electrical conductor into a good conductor. The scientists, in effect, engineered the material to get a desired result.

Before scientists can go about an orderly engineering of materials having special properties, however, an

enormous amount of information must be amassed. The very first step is to learn the properties of pure materials. These properties are controlled by the crystal lattice structure, the way the atoms join to form larger units. Any imperfection in the lattice structure, or an increase in the kinds and amounts of impurities, can change the material's nature.

Then more information must be amassed as outside factors are brought to bear on the substance. These factors can be pressure, temperature, atomic radiation and the atmosphere surrounding the substance. A promising rocket material that withstands high temperatures might be found to lose this quality completely when subjected to the cosmic radiation found in space. Or perhaps the material might become even more heat resistant.

Once such information is available for a large number of chemical mixtures and compounds, scientists can take more of a slide-rule approach to the design of specific materials to meet specific needs.

One storehouse for this kind of data is at the National Bureau of Standards in Washington, D. C. Scientists there are constantly working out the factors that affect the properties and behavior of materials.

Even more critical work at the Bureau involves the development of measuring techniques. To assure valid results, these measurement methods must be able to guarantee the scientist that he is actually measuring what he wants to measure.

To illustrate the measurement problem, Dr. Irl Schoonover, the Bureau's associate director for planning, said

that when some property of a sample material is measured independently in several laboratories throughout the U. S., the results often vary widely. Before molecular engineering can get down to an exact science, all laboratories must be able to measure specific qualities and get consistent results.

Dr. Schoonover does not see the Bureau as a creative source of new, exotic materials. In advancing the art of molecular engineering, he foresees the Bureau contributing chiefly through development of "very fine methods to enable others to make the materials."

These methods will include ways to prepare the material, to purify it, and to characterize its qualities through accurate measurements.

In the past, an enormous amount of work has been done in this field. Much of it, unfortunately, is of limited value.

One limitation is the temperature range at which materials were tested. Until recently, materials were studied at temperatures ranging up to about 2,700 degrees Fahrenheit. Suddenly rockets made material performance at much higher temperatures important.

Complicating the picture is the fact that composition of the materials studied was often not determined to a high accuracy.

"For instance," Dr. Schoonover said, "we speak of aluminum oxide as Al_2O_3 . But a given sample of aluminum oxide may actually be a spectrum of compounds perhaps ranging from $\text{Al}_2\text{O}_{2.9}$ to $\text{Al}_2\text{O}_{3.1}$. This variation in composition may produce variations in properties of the sample."

Similarly there is a lack of knowledge surrounding the other factors that controlled the properties of the material studied.

These are some of the things that limit the value of past work. The researcher may have tested aluminum oxide to 2,700 degrees, but what kind of aluminum oxide?

Strange things sometimes happen under the many forces that can act upon a material, Dr. Alan D. Franklin, chief of the Bureau's mineral products division, said.

At frigid temperatures approaching absolute zero, for instance, liquid helium climbs the walls of its container. Some metals suddenly lose all electrical resistance and an electric current induced in them theoretically will circulate forever if the metal is kept that cold.

When water freezes, it becomes ice. When extreme pressures are exerted, it becomes a different type of ice. And then another type. All told, there are at least five different types of ice.

Under high pressure, new chemical compounds have been formed. Man has also been able to use pressure to produce in the laboratory things that so far have existed only in nature. For example, graphite, under pressure, can be made into diamond. Quartz, a special form of silicon dioxide (sand), can be made into Coesite.

Coesite represents an entirely new form of silicon dioxide. It is much denser than quartz. After being formed under high pressure, Coesite can be trapped in this state by releasing the pressure and cooling to room temperature. Coesite did not exist prior to high-pressure work on silicon dioxide.

Also at high pressures it has been found that some electrical insulators become semiconductors, and brittle substances such as bismuth and quartz become ductile. Tungsten carbide more than doubles its strength when under a pressure of 400,000 pounds per square inch.

It can be seen that a staggering panorama of material characteristics to be explored — and exploited — confronts the researcher in the molecular engineering field.

The qualities of materials are affected not only by external factors but also by their impurities, porosities, grain size, grain boundaries, lattice dislocations, strains, crystal imperfections, and ability of the surface to absorb liquids, solids and gases.

Each of these must be evaluated independently for each substance. This information is now being gathered and scientists are beginning to approach the point where "we can build in the qualities we want," Dr. Schoonover said.

Much work remains to be done before scientists will be able to engineer the materials they need. But the scope is so wide and the possible combinations of controlling factors is so astronomical that, once these are properly understood, it appears that a whole array of new and exciting materials some day can be created.

Many of these materials, if made right now, would be hailed as fantastic "breakthroughs."

These "breakthroughs" in the creation of new materials will be essential in advancing technology. In a very real sense, the future stature of America now rests heavily upon the shoulders of the molecular engineer.

Rydberg Constant Confirmed

► The National Bureau of Standards has re-evaluated data used in an early determination of the Rydberg constant, increasing accuracy by a factor of ten, and bringing this earlier calculation into line with the presently accepted value.¹ This work, by W. C. Martin of the Bureau staff, constitutes, in effect, an independent confirmation of the value of the Rydberg constant, which since 1952 has been based on the work of only one set of observers.

The Rydberg constant, R_∞ , which relates the energy levels in atoms, enters into the frequency or wave-number formulas for all series in atomic spectra. It is at present the most accurately known combination of fundamental atomic constants; a simple formula links its value to the mass of the electron m , the electron charge e , the speed of light c , and Planck's constant h . The "primitive," or less accurately known constants, such as h , are adjusted to satisfy the value of R_∞ . Because of the importance of the Rydberg constant, employing a value that had been directly confirmed by only one group was very unsatisfactory. The Bureau therefore undertook the present work which has succeeded in putting the Rydberg constant on a firmer footing.

This evaluation was carried out as part of a broader program which seeks to obtain more accurate values for important physical constants, such as the velocity of light, the acceleration of gravity, and the various atomic constants. These constants of nature, when determined to extremely high accuracy, provide *invariant* bases for

the reproduction of standards of many physical quantities such as length, time, and electric current. They thus serve to lock present standards and units of physical measurement into the phenomena of science. Because the Rydberg constant is basic to the modern theory of the atom, it provides a connecting link between atomic constants and the accepted standards of measurement.

The value of the Rydberg constant in use today is based on the work of Drinkwater, Richardson, and Williams.² These observers measured the position of lines in the hydrogen spectrum against the primary standard wavelength of the red cadmium line. From the measured wavelengths of the transitions and the theory of the hydrogen atom, they calculated R_∞ . This determination was modified by Cohen in 1952 in the light of increased knowledge.³ The result was accepted as an accurate value, although it differs significantly from the earlier results obtained independently by Houston⁴ and Chu,⁵ which were also adjusted by Cohen. As these two earlier experimenters measured lines in the hydrogen and helium spectra by using the 5016-A line of helium as a reference, it was thought that the source of error might be in the wavelength of the helium line.

The Bureau's work shows that this was indeed the case. The helium 5016-A line has been remeasured and the proper substitutions made in the calculations of Houston and Chu. The value obtained for R_∞ by combining all the modern determinations is

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► W. C. MARTIN of the National Bureau of Standards aligns the projecting lens of a system used in measurements to re-evaluate the Rydberg constant. This work involved measuring the wavelength of the 5016-Å helium line against a mercury standard. Light from a liquid-nitrogen-cooled helium lamp (immersed in Dewar, lower right, equipped with windows) passes through a partially transmitting mirror into the interferometer along with light from the mercury-198 lamp (lower center) which is reflected into the interferometer by the same mirror. The resulting fringes are then projected onto the slit of a large prism spectrograph (upper left). A comparison of the helium fringes thus obtained with the fringes due to mercury lines of known wavelength allows a very accurate determination of the wavelength of the particular helium line involved in calculating the Rydberg constant.

$109737.312 \pm 0.008 \text{ cm}^{-1}$. This result is in excellent agreement with the presently accepted value ($109737.309 \pm 0.0012 \text{ cm}^{-1}$).

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3. The Rydberg constant and the atomic mass of the electron, by E. R. Cohen, *Phys. Rev.* 88, 353 (1952).
4. A spectroscopic determination of c/m , by W. V. Houston, *Phys. Rev.* 30, 608 (1927).
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Chemistry Course X

► "CHEMISTRY X," a new kind of course without grades or examinations, where students will think creatively about chemistry by engaging in moderated discussions, will make its appearance for the first time at Stevens Institute of Technology, Hoboken, N. J., during the spring term.

Undergraduates from freshmen to seniors will grapple with such modern chemistry topics as new types of plastics and their use in missiles; fuel cells, which create electricity directly by combining hydrogen and oxygen; the biological effects of nuclear fallout; the chemistry of heredity; and the effect of certain drugs on cancer.

According to Dr. Luigi Z. Pollara, Head of the Chemistry-Chemical Engineering Department, "This is one course where right answers are relatively unimportant. We want students to probe chemistry with the same intensity and depth as they do politics, religion and ethics. We hope to stimulate their imagination by exposing them to exciting topics usually not

covered in formal courses."

Chemistry X instructors will vary from meeting to meeting and will be drawn from different Stevens departments. Discussions will include any topic in chemistry directly related to the students' lives.

Dr. Pollara, for example, plans to talk on combustion in automobile engines and to explore the nature of chain reactions and explosions. However, there will be no formal lectures. Faculty members will give brief introductions designed to initiate student discussions. The professors then act as moderators.

The course will meet once a week. Material will be presented in such a way that freshmen as well as upperclassmen will be able to follow and participate in discussions.

Since the subject matter will continually change and will cover a wide range of topics, students can take the course for their four years at Stevens. The only pre-requisite is willingness to give up some of their free time.

New Coat for Columbium

► THE U. S. NAVAL Research Laboratory, Washington, has developed a metallic coating for columbium metal that will protect it against oxidation at temperatures as high as 2,200 degrees Fahrenheit.

Development of the coating is believed to be a first step toward use of this high-strength metal at temperatures that turn iron, nickel and cobalt into soft putty. It may be especially useful for glider vehicles design-

ed to return man safely to earth from an orbit in space.

Using zinc as a starting material, the coating forms a protective layer of complex zinc-columbium oxide that serves as an "envelope" for the columbium metal.

The new coating is ductile and plastic at high temperatures and "heals" itself if bare spots develop, reports the Naval Research Reviews (Dec., 1959).

Pea-Sized Receiver Forecast

► A NEW CONCEPT of molecular electronics demonstrated may lead to development of a complete communications receiver the size of a pea.

The new concept is said to "leapfrog" over current attempts to make electronic systems smaller and more reliable. Its further development may mean the eventual elimination of such components as resistors, capacitors, diodes and transistors.

The new technique, demonstrated by the U. S. Air Force and Westinghouse Electric Corporation, "grows" semiconductor crystals in the form of long, thin, near-perfect ribbons, or dendritic strips. The dendrites can be incorporated into finished semiconductor devices without intermediate material processing of any kind.

Westinghouse scientists have grown multi-zone crystals, called "functional electronic blocks," that provide the basic building blocks required in molecular electronic systems. Each one is a complete functioning electronic sub-system.

A variety of working sub-systems shown were vastly more reliable than the most advanced electronic devices in use today and as much as 1,000 times smaller.

Dr. S. W. Herwald, Westinghouse vice-president in charge of research, demonstrated an amplifier used in a high fidelity phonograph in which the pre-amplifier was the size of a match-head and the power amplifier was smaller than a dime.

"If this can be accomplished now," he said, "it isn't difficult to foresee development of a complete communications receiver the size of a pea within a few years."

Also shown was a wafer-sized direct current power amplifier that required only the energy from a flash-light beam to control 40 watts of power for two 12-volt automobile headlamps.

New systems employing these concepts, the demonstrators pointed out, could be operational in missiles or

satellites in three to four years to perform such functions as telemetering light intensity or radiation levels back to earth and providing infrared detection and reconnaissance information, flight guidance and communications.

To construct molecular electronic systems, Dr. Herwald said, it is first necessary to determine the desired

electronic functions to be performed and then build those functions into a single piece of semiconductor material such as silicon or germanium.

By such techniques as plating, etching and alloying, the structure of the tiny solid piece is arranged to perform the identical functions that now require many individual components that have to be soldered together.

Cure for Salt Corrosion Sought

► CORROSION - preventing chemicals which cut down damaging effects of salts used for snow removal are now being tested. Such substances can help protect automobiles in wintertime when metal-eating salts are scattered on highways and driveways to melt snow and ice.

Most commonly used in melting the ice are two old salts, calcium chloride and rock salt, which is the crude form of ordinary salt, sodium chloride. These substances, used separately or together in mixtures, are corrosive, not only to automobiles but to highway surfaces as well.

The problem has come to the attention of research groups sponsored by the National Association of Corrosion Engineers. Prof. Walter H. Bruckner of the University of Illinois,

vice-chairman of NACE's Committee on Corrosion by De-icing Salts, said that chemicals are being tested which may be mixed with the de-icing salts to limit corrosive damage. Some of the "inhibitors" tested were sodium aluminate, sodium chromate and potassium chromate.

Results so far have not been as successful as the committee would like, and they are searching for other substances.

Inhibitors are being tried on public roads by highway departments.

Prof. Bruckner said that the automotive industry and the U. S. Air Force are interested in the project. Air Force personnel found that de-icing salts used to melt snow from runways are particularly harmful to the aluminum metal on their planes.

Rocks Dated by Heating Method

► A NEW METHOD of dating the age of past civilizations based on heating their rocks and pottery is now available to help the historian and archaeologist.

Thermoluminescence, caused by radioactivity in all sorts of materials

and displayed when they are heated, is the basis of the new method.

Announced to the American Association for the Advancement of Science in Chicago by Drs. George C. Kennedy and Leon Knopoff of the University of California Institute of

Geophysics at Los Angeles, the method is extremely simple and speedy.

The material, usually pottery or lava, is heated to below the point where it gives off light itself. This releases thermoluminescence, which is caused by electrons being freed from the solids in which they have been trapped for the many years.

All materials contain traces of radioactive elements. Over the years this radioactivity decays, giving off alpha and beta particles which trap electrons in solid crystals. The older the material, the more electrons are trapped.

When the material is heated up to about 350 degrees centigrade or less, the electrons are given back and create a mild light that can be captured by a photomultiplier tube. The more light, the older the material is.

The method is good for about 100,000 years in the past and it therefore supplements beautifully the dating of ancient civilizations by carbon isotope 14 which has been so successful for samples up to 40,000 years old. Dr. Knopoff, in presenting the paper, told of dating 16 fragments of ancient Athenian pottery, dishes, lamps, cups,

vases and wine jugs, which were known to have come down from the Ninth Century B. C.

The thermoluminescence method checked with the historical date. Lava rocks from northern Arizona were dated back to 15,000 years ago.

It is expected that this new method will be particularly significant when used on Mayan and Mexican pottery, and it should solve the puzzle of the Mayan calendar. The method has been tied in with the dates in the Southwest determined by the study of tree rings and it will make possible a wide extension of the times at which early American civilization is known to have existed.

The new method is especially useful for civilizations which have left their records, not in wood and charcoal, but in their distinctive pottery.

Many of the past records have undoubtedly been lost because of the decay and rot of wood or the fact that later civilizations burned the records of the previous civilizations, which might otherwise have been dated from the tree rings or by the carbon-14 dating method.

Exploding Wire May Drive Rocket

► BY PUMPING enormous amounts of electricity into a tiny wire, causing it to explode, scientists have discovered what they believe to be a promising way to power a space rocket. Specific impulses, the rocket engineer's equivalent of miles per gallon, far superior to those of chemical fuels have been achieved.

They were obtained using alumin-

um wire through which electricity from a 10- to 20-kilovolt source was discharged in seven thousandths of a second. Scientists at Electro-Optical Systems, Inc., Pasadena, Cal., said engineering problems that would be involved in producing successive explosions in a rocket are formidable, but that such a system would have "extremely attractive features."

Book Condensations

ELEMENTS OF ION EXCHANGE—Robert Kunin — *Reinhold*, 164 p., illus., \$5.75. Basic treatment of ion exchange techniques.

THERMODYNAMIC PRINCIPLES for Chemical Engineers—Roger Gilmont — *Prentice-Hall*, 339 p., illus., \$11. Exposition of thermodynamic fundamentals as applied to chemical systems.

CHEMISTRY FOR SANITARY ENGINEERS — Clair N. Sawyer — *McGraw*, 367 p., illus., \$9.50. Discusses fundamentals of chemistry on which sanitary engineering practice is based.

HEALTH FACTORS IN SAFE HANDLING OF CHEMICALS — *Manufacturing Chemists Assn.*, 4 p., 15¢, direct to publisher, 1825 Conn. Ave., Washington 9, D.C. Recommended safe practices.

THERMOCHEMISTRY FOR STEELMAKING, Vol. I — John F. Elliott and Molly Gleiser — *Addison-Wesley*, 296 p., \$10.50. Information on pertinent chemical properties and some physical properties of important elements and compounds.

HANDBOOK OF ELECTROCHEMICAL CONSTANTS — Roger Parsons — *Academic*, 110 p., \$6. Pocket-size reference work of tables.

THE SEA OFF SOUTHERN CALIFORNIA: A Modern Habitat of Petroleum — K. O. Emery — *Wiley*, 366 p., illus., \$12.50. Brings together material on various aspects of the sea floor, the water, and the marine life off California.

HISTOCHEMISTRY: Theoretical and Applied — A. G. Everson Pearse — *Little*, 2nd ed., 998 p., illus., \$20. Covers the whole of histochemistry as applied to tissue sections, evaluating available methods.

PROGRESS IN INORGANIC CHEMISTRY, Vol. I — F. Albert Cotton, Ed. — *Interscience*, 566 p., illus., \$14.50. Articles on leading research in the field.

HYDROGEN BOND — George C. Pimentel and Aubrey L. McClellan — *Freeman*, 475 p., illus., \$11.40. Complete coverage of the subject, with annotated bibliography of more than 2,300 references.

UNDERSTANDING CHEMISTRY — Lawrence P. Lessing — *Interscience*, 192 p., illus., \$3.50. Summary of chemistry's basic laws and their application in everyday uses.

THE FUTURE OF SCIENCE, with a "Self-Portrait" of the Author — Bertrand Russell — *Philosophical Lib.*, 85 p., \$2.75. Reprint of 1924 essay, and transcript of a recent BBC interview.

OPTICAL MINERALOGY — Paul F. Kerr — *McGraw*, 3rd ed., 442 p., illus., \$8.50. Extensive revision of Rogers and Kerr's work, covers new discoveries and developments, such as the polarizing microscope. Mineral descriptions rewritten and extended.

CHEMISTRY FOR OUR TIMES — Elbert C. Weaver and Laurence S. Foster — *McGraw*, 3rd ed., 666 p., illus., \$5.72. Elementary chemistry using inductive approach, with emphasis on principles.

CEMENTED CARBIDES — Paul Schwarzkopf and Richard Kieffer — *Macmillan*, 349 p., illus., \$15. Deals with composites of pure refractory material and binder metal of high ductility, including ceramic tool materials.

MINERAL EQUILIBRIA at Low Temperature and Pressure — Robert M. Garrels — *Harper*, 254 p., \$6. About chemical relations in aqueous solutions at low temperatures and pressures.

NEW WORLD OF CHEMISTRY — Bernard Jaffe — *Silver Burdett*, rev. ed., 678 p., illus., \$4.96. High school chemistry textbook updated.

TURBULENCE: An Introduction to Its Mechanism and Theory — J. O. Hinze — *McGraw*, 586 p., \$15. Fundamentals of turbulent flows for the chemical engineer.

AMMONIA: Manufacture and Uses — A. J. Harding — *Oxford Univ. Press*, 41 p., illus., \$1.05. Describes modern industrial conditions.

SEMIMICRO EXPERIMENTS IN GENERAL CHEMISTRY AND QUALITATIVE ANALYSIS — Nicholas D. Cheronis and Herman Stein — *De Graff*, 310 p., illus. by E. Gumberg, paper, \$5.50. Guide to experimentation, using small scale equipment.

Diagnosing Bone Diseases

► DISEASES of the bone may be diagnosed through a new procedure which features the use of strontium-85, a safe relative of hazardous strontium-90, the fallout product.

The procedure, developed by Dr. Norman S. MacDonald of the University of California Medical School, Los Angeles, is described in a report just published by the University.

The technique, known as an osteogram, employs tiny tracer amounts of strontium-85, which is rapidly absorbed by bone when it is injected into the body.

By placing special radioactivity detecting scintillation counters over the bone area to be studied, the rate of absorption or deposition of the strontium can be measured.

In preliminary studies of patients with various bone diseases it has been

demonstrated that the rates of absorption differ in diseased bone areas from those of normal bone.

Furthermore, there seem to be differences in these rates in various types of bone diseases. Thus the osteogram patterns might be useful in determining that bone disease was present and in telling what the nature of the disease is.

Bone diseases studied with the new technique to date include osteoporosis, a disease characterized by spongy fragile bone; Paget's disease, a skeletal disorder; and various types of bone cancer.

Dr. MacDonald said the osteogram is useful in following progress of repair of bone fractures and treatment of bone disease as well as in obtaining additional basic knowledge about bone chemistry.

Chemistry Comments

Interesting facts in the chemical world.

- The process by which blood coagulates has been studied for a century and it still is not fully understood.
- The best-known natural asphalt deposits in the Western Hemisphere are the 115-acre asphalt lake of Trinidad and the 1,000-acre Bermudez deposit in Venezuela.
- Asphalt was used as paving-stone mortar by the Egyptians and Mesopotamians as early as 3800 B.C.
- The Great Salt Lake in Utah has a 25% salt content which makes it difficult for a swimmer to sink.
- A new mining technique, called tubbing, uses a cast iron lining inside the mine shaft for greater safety and efficiency.
- Many nuclear projects require the use of highly refractory materials, such as very pure magnesium oxide.
- Chlorine in the form of ordinary household laundry bleach now is being used effectively to correct sulfur water problems.
- Kyanite, a member of the sillimanite group of minerals, has become an essential material in the manufacture of many ceramic products.
- Some 3,500 years ago, iron had five times the value of gold and 40 times the value of silver.
- Sixty-three percent of U. S. rubber consumption goes into tire and tube products.
- Cosmic radiation intensity does not vary greatly over the course of a day or year, thus indicating that the source of much of it is not the sun.
- Of the 101 elements now known to man, 85 are of a metallic nature.
- The world's oil is expected to last for 500 years at present rates of consumption.
- Calcined alumina is used chiefly in the production of aluminum, but large quantities are also used in making refractory bricks and cements, spark plugs, insulators, and porcelain and glass mixes.
- The rare earth elements compose about one-fourth of the known metals.
- The Chinese were the first to develop the process of making paper from fibers, using a compound of silk, old linen and fish nets, in the first century A.D.
- Until the late 1800's, all paper was made from cloth, preferably linen, which was usually in short supply.
- Wood is 50% cellulose, 30% lignin and 20% carbohydrates, protein, resins and fats.
- Paint removers using methylene chloride give the widest and fastest action of any nonflammable paint removers.
- Although sodium is found in plants, there is no evidence that it is necessary for growth.

- Helium-3, an isotope of helium, contains more protons per neutron than any other isotope and, therefore, forms a unique tool for producing nuclear reactions.
- The National Vitamin Foundation, supported by manufacturers and distributors of bulk and dosage form vitamins, subsidize both basic and clinical research as well as various professional, educational projects, in the nutritional sciences.
- Tektites are small chunks of black glass whose origin is unknown but which may come from outer space.
- The American Chemical Society is the world's largest professional association of scientists, including 88,000 chemists and engineers.
- U. S. production of primary magnesium in 1959 was 31,000 tons, an increase of 1,000 tons over 1958.
- Oxygen plus nitrogen make up about 99% of the atmosphere, the rest being composed mainly of the inert noble gases.
- Iron was more precious than gold in 1600 B.C.
- About 1,000,000 pounds of castor oil were used in plastic urethane foams in 1958.
- U. S. spending for drugs and medical appliances during 1958 totaled \$4.4 billion.
- Ozone, a very active form of oxygen that normally dwells in high altitudes where it performs a valuable radiation screening action, has been found to be increasingly invading our part of the air close to the ground.
- American Rocket Society statistics show the death rate of persons participating in amateur rocket experiments is 12.5 per 10,000 per year.
- U. S. companies have spent more than \$12 billion looking for oil and gas in the last five years and the search gets costlier every year.
- Nickel steel is 50% stronger than ordinary carbon steel.
- Eight out of nine U. S. wells drilled in search of new oil and gas deposits do not pay off.
- The average man of 170 pounds contains about 110 pounds of water.

On the Back Cover

➤ ON BACK COVER *this month is a further illustration of the lead story, and shows an application of the double diffusion process, for the preservation of wood, which was developed at the Forest Products Laboratory of the U. S. Department of Agriculture, at Madison, Wisconsin.*

New wood is alternately soaked in aqueous solutions of copper sulphate and sodium arsenate. These two chemicals react within the wood to form copper arsenate. This chemical is insoluble in water and therefore remains in the wood while the other chemical formed, sodium sulphate, is soluble and is in time leached out. Copper arsenate is highly toxic, and destroys both decay organisms and living creatures. Fence posts, like those being treated in the picture, have remained in the ground for eighteen years without harm.



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